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## ORIGINAL ARTICLES.

### I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(PLATE XIV.)

In these notes it is my object to describe and figure some of the more important Chalk Polyzoa that have not yet been described, or have been described from material less complete than mine.

#### Genus HOMALOSTEGA, Marss.

This genus has been dismembered by Canu,[1] who distributed the species grouped under it by Marsson among various genera of his Diplodermiata; but they all appear to belong to his Monodermiata and have enough in common to justify the retention of a most convenient genus.

Homalostega anglica, nov. Pl. XIV, Figs. 1 and 2.

*Zoarium* always adherent, growing strongly in all directions.

*Zoœcium* very tumid; aperture subterminal, subtriangular, sides very faintly inflexed, lower lip very faintly curved inwards and bearing a well-marked raised rim, deep slits at the corners.

*Avicularia* accessory, abundant, laterally symmetrical; they sometimes remain rudimentary in the mature stages of the zoarium (Fig. 2), but normally they become half as long as the zoœcia, round below and tapering gradually upwards to a point, with a small arrowhead-shaped aperture into which project two denticles which are rarely preserved. They lie almost always with their long axes approximately parallel to the lines of growth.

*Homalostega anglica.* Avicularium highly magnified.

*Oœcia* unknown, unless occasional inflations of the upper lip of the aperture and the front wall adjoining it are oœcial in nature. Very abundant at Trimmingham, where, and at Norwich and Sherringham, I recorded it in error as *H. pavonia*, Hag. sp., from which, judging

[1] "Revision des Bryozoaires du Crétacé figurés par D'Orbigny": Bull. Soc. Géol. France, 1900, p. 338 et seq.

by Marsson's figures and description [1] (Hagenow's figures and descriptions being inadequate), it is easily distinguishable by the shape of the aperture.

Homalostega biconvexa, nov. Pl. XIV, Figs. 3 and 4.

*Zoarium* resembling that of *H. anglica*.

*Zoœcia* tumid, but less so than those of *H. anglica*. Aperture subterminal, biconvex; upper lip semicircular, lower lip very faintly curved outwards in the centre, more so at the sides; shallow slits in the corners.

*Avicularia* accessory, very abundant, with broad rounded bodies and rapidly tapering pointed beaks which are generally bent round the head of a cell; aperture occupying the greater part of the area, spanned by a bar; when this is broken away the aperture is arrowhead-shaped or diamond-shaped. They lie almost invariably at a distinct angle to the lines of growth and often in pairs, one on either side of a cell and almost meeting round its head.

*Oœcia* not observed.

Abundant at Trimmingham.

Homalostega vespertilio, Hag. sp. Pl. XIV, Fig. 5.

Neither Hagenow [2] nor Marsson [3] appears to have observed vicarious avicularia in this species. It is very abundant at Trimmingham, and though most colonies, including some of the largest, show no vicarious avicularia, in some they occur capriciously, and I have figured part of a colony in which they are exceptionally numerous. They may be described as ordinary zoœcia of which the apertures have been drawn out to a great length.

The species is very prone to occur as a free unilaminate sheet separated by a very thin layer of chalk from the surface of some fossil.

Homalostega cuniformis,[4] nov. Pl. XIV, Figs. 6 and 7.

*Zoarium* unilaminate, generally adherent.

*Zoœcia* very large; irregular growths, to which this species is very prone, often simulate fragments of a dividing wall, or make two cells apparently confluent. Aperture subterminal, semicircular; the lower lip has a broad raised rim; the upper lip rises rapidly from the lower lip owing to the strong inflation of that part of the cell which surrounds the upper lip, making it stand up like the hood of a cradle, and it thickens as it rises.

*Avicularia* intercalated as initial cells of new lines. Relatively narrow, highly inflated with a central circular aperture from which runs a long, slightly tapering, symmetrical beak consisting of two side walls enclosing a slightly depressed front wall, which at the tip is sharply expanded.

*Oœcia* occurring very capriciously, very globose.[5]

Occurs sparingly, but in large colonies at Trimmingham.

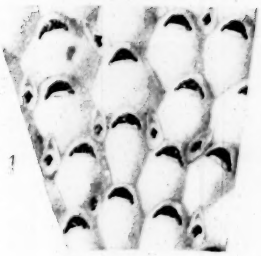
[1] "Bryozoen der Weissen Schreibkreide der Insel Rugen": Pal. Abh., Band iv, Heft i, p. 93.

[2] *Neues Jahrbuch für Mineralogie*, etc., 1839, p. 270.

[3] Op. cit., p. 94.

[4] From *cunæ*, a cradle.

[5] The free edge produced over the aperture of the zoarium.



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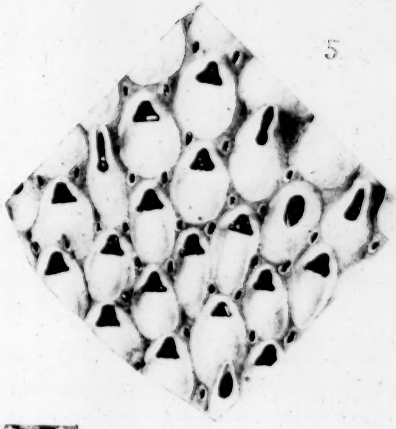

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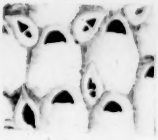


4.

7.

*R. M. Bryozoa phot.*

New Chalk Bryozoa.

EXPLANATION OF PLATE XIV.

Fig. 1. *Homalostega anglica.* × 20.
,, 2. Ditto, with rudimentary avicularia. × 20.
,, 3. *Homalostega bicouvera.* × 20.
,, 4. Ditto, with perfect avicularia. × 20.
,, 5. *Homalostega vespertilio.* × 20.
,, 6. *Homalostega cuniformis.* × 20.
,, 7. Ditto, diagrammatic longitudinal section through cell.

(*To be continued in our next Number.*)

## II.—Notes on the Structure and Physiography of the Tarntal Mass.

By Alfred P. Young, Ph.D., F.G.S., etc.

(PLATES XV–XVIII, WITH DIAGRAM AND MAP.)

THE mountain mass known as the Tarntaler Köpfe, situated about 20 kilometres south-east of Innsbruck, is distinctly isolated from other high ground in the vicinity. The peaks rise to heights approaching 2900 metres above sea-level. The geologic features above the level of 2000 metres are of special interest. The adjacent country is occupied by crystalline phyllites, chiefly displayed on the north, and highly foliated calcareous schists developed mostly on the south of the mountain.

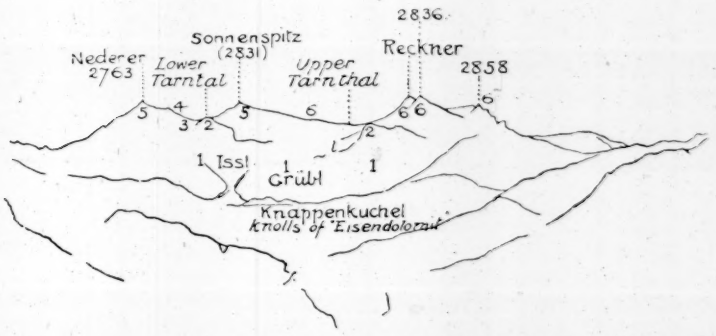



Fig. 9. Diagram illustrating the section (see *infra*), to be compared also with Pl. XV, Fig. 1. The sequence is indicated by the same numbers as on p. 340.

A remarkably large corrie or cirque can be recognized in the accompanying figure, which is a photograph of the mountain from the west (Pl. XV, Fig. 1). The nearer rock-mounds ('Knappenkuchel' of the inhabitants) on the lip of the corrie consist of a dolomite with a reddish weathered surface, the 'Eisendolomit', which rests directly on the phyllites. The section to which attention is here more particularly directed commences at the back of the corrie at about 2150 metres above sea-level with a massive grey dolomite in which no stratification has been detected.

The section from the floor of the corrie, called 'Grübl', to the summit of the Nederer, is as follows (from above downwards No. 1, being lowest):—

5. Green quartzite schists, with red hæmatite schists, with well-developed plane parallel jointing, frequently with well-marked banding transverse to the foliation (see Pl. XVI, Fig. 3) . . . . . 73 metres.
4. Band of dolomite freely penetrated by quartz veins, with dolomite breccia, here called 'Tarntal dolomite'. This rock, broken rather than sheared, has been kneaded into the schists by the folding movements . . 75 metres.

*Zone of maximum contortion.*

3. Calcareous schists showing conspicuous mechanical foliation. 95 metres.
2. Limestones distinctly bedded with dip to north-east, otherwise little disturbed . . . . . 40 metres.
1. Massive dolomite, unstratified, showing brecciation in places without signs of shearing . . . . . 330 metres.

The continuation of the series is best shown in the Upper Tarntal, a little to the south of the above. On the floor of the valley, at about 2600 metres, the flaggy limestones, more crumpled than in the Nederer section, are seen to dip to the south under the highly disturbed dolomite (the equivalent of No. 4 in the above section). The slope of the Reckner just above is occupied by hardened schists of the same group as those seen at the Nederer summit. On these rests the great mass of the Reckner Serpentine, some 260 metres in depth.

The intrusive character of the serpentine is well seen at several contacts with the schist, but more especially in a row of occurrences crossing the valley of the Upper Tarntal in a northerly direction. On the steep scarp over the Lizumtal on the east side of this valley is a small occurrence of serpentine completely embedded in the schists. The junction of schist and serpentine is very irregular. The injection at the contacts of small veins and lenses of basic magma into the schists has been described in an earlier paper.[1] The penetration of the serpentine into the schist has taken place for the most part along the foliation planes, which are here crossed by the bedding planes, showing that the foliation was already developed at the time of the intrusion.

As far back as 1859[2] Adolf Pichler announced the discovery of Belemnites and other fossils in place, and affirmed the Liassic age of the higher beds in this locality. In a personal communication addressed at a much later date to Professor Rothpletz, Pichler mentions a specimen of *Ammonites radians* which he collected here and sent to Vienna: this fossil cannot, it seems, be traced. Since that time the only organic remains found have been certain Brachiopods, Lamellibranchs, and corals pronounced to be of Rhætic age.[3]

[1] A. P. Young, "Stratigraphy and Structure of the Tarnthal Mass": Q.J.G.S., November, 1908, vol. lxiv, pp. 596–603.

[2] "Beiträge zur Geognosie Tirols": *Zeitschrift des Ferdinandeum*, 1859.

[3] A. Rothpletz, *Querschnitt durch die Ostalpen*, 1894, p. 75. The fossils named are: *Terebratula gregaria*, *Modiola minuta*, *Gervillia præcursor*, *Corbula alpina*, *Pecten* sp., *Thecosmilia* cf. *fenestrata*, Reuss, and cf. *Convexastræa Azzarolæ*, Stopp.

Figs. 1, 2. The Tarntaler Kopfe.

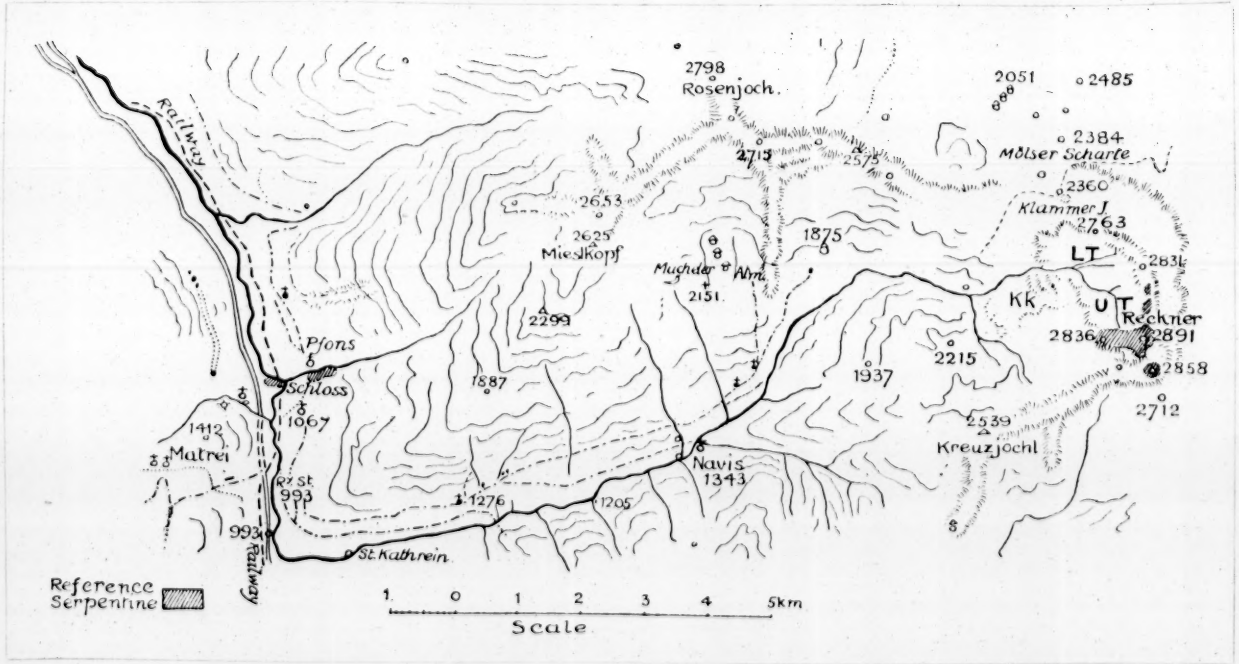



FIG. 10. Sketch-map of the district between Tarntaler Köpfe and Matrei, showing occurrences of serpentine. Height above sea-level in metres from the Generalstabskarte. U.T. Upper Tarntal; L.T. Lower Tarntal; Kk. Knappenkuchel.

So far there exists no tangible evidence of the presence of a Cephalopod fauna in these rocks.

In the summer of 1907 a plate of limestone bearing an Ammonite was found by me at a height of nearly 2500 metres above sea-level on the surface of a scree-cone which has accumulated under the high hanging valley known as the Lower Tarntal. The fossil and its cast were seen lying within 2 feet of one another near the end of a trail of limestone flakes evidently brought down by recent avalanches from the steep cliff at the lower end of the high valley. Somewhat lower on the slope of the same cone, called 'Issl' by the inhabitants (Pl. XVII, Fig. 5), a fragment with a portion of a Belemnite was found. Mr. G. C. Crick, of the British Museum, has kindly undertaken the description of these fossils. These organic remains, like most from the same source, are ill-preserved. It seems nevertheless desirable to keep a record of all such finds for future reference, in the hope that the accumulated material may in the end throw light on the difficult problems here presented.

It may be well to explain that an erratic origin for these fragments is out of the question. All the material of the scree-cone is represented in the standing rocks on the slopes of the Tarntal above. The movement of snow and ice was always in a downward direction. The ravines radiating in all directions are tributary to deep-cut valleys with capacity sufficient to carry off all the ice of this and the neighbouring heights, and the narrow ridges separating the valleys offer no surface along which the ice from the nearer mountain-masses could have been forced up to this level.

At times of highest glaciation the snow-limit must have stood at a level very much lower than that at which these fragments were found. This limit for the Alps is given at 1400 to 1700 metres; under exceptional circumstances it may have reached 1900 metres.[1]

Near this level were the sources of the masses of ice on which depended the transport of blocks to great distances. Obviously no block could be carried above the snow-limit. During stages of advance or retreat, when the snow-line approached 2500 metres, the glacier-tongues were much shortened and left their loads at short distances from the roots.

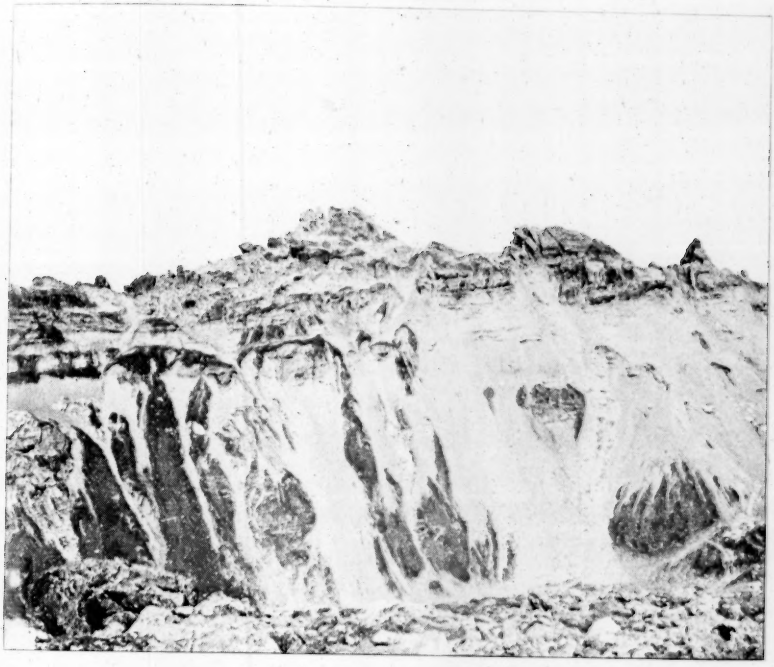
During the summer of 1908 I again searched this and other screes of similar material, but more especially the standing rocks, the bedded limestones of the cliff above mentioned, and other localities.

The surface of the flake bearing the ammonite is seen to be roughened by minute protuberances, suggesting at first sight an oolitic structure. Many fragments of the same character can be found on the scree-slope of the Issl.

Microscopic slides were prepared from several of these flakes. In a groundwork of comminuted material are embedded larger fragments of calcite, on which the microscope shows structures evidently of other than mineral origin. Dr. Bather, of the British Museum, who kindly examined some of these sections, noted in many of the fragments the reticulate structure belonging to Echinoderms. In

[1] Penck & Brückner, *Die Alpen im Eiszeitalter*, about 1908, p. 1143.

3



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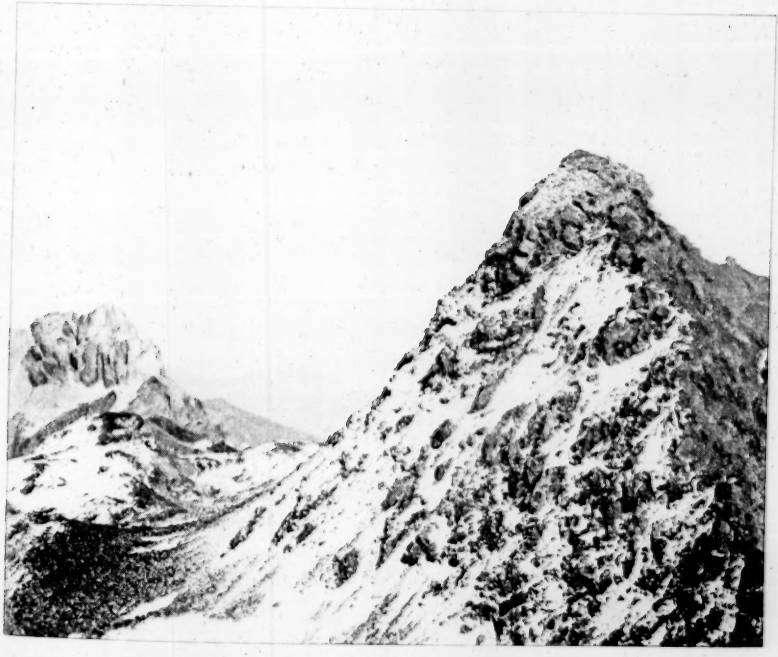

Fig. 3. The ridge of the Nederer

one instance a section of an Echinoid radiole of Diademoid type could be recognized. This form is probably not older than Upper Trias; the slide on which it occurs was taken from the flake of limestone bearing the Ammonite.

Markings, similar to those above described, are to be seen in microscope sections from the standing rock of the cliffs above the Issl. These observations are in keeping with the conclusion already arrived at as to the source of the fossil.

The breccias of the Tarntal band (No. 4 of section, p. 340) have characters which distinguish them from the breccias which form a small part of the little disturbed mass of Triassic dolomite below (No. 1 of the section). The latter contain little or no quartz; the fragments and matrix are similar in character and are with difficulty distinguished. In the Tarntal band the fragments vary in character, and on weathered surfaces show up well against the matrix; some of the fragments show the original bedding planes. On the Mieselkopf ridge angular flakes of a phyllite nearly a foot in length have been seen among the inclusions in a similar rock. In the Upper Tarntal was found a small block of the breccia which contained numerous inclusions of green tale, a mineral not infrequent in the schists near the serpentine contact.

The question arises—Is the brecciation of the Tarntal dolomite an œcogenous or an apœcous character, i.e. has it been acquired before the rock left its original site or during the movement of translation? Reasons will be given for the view that both brecciation and veining with quartz are œcogenous.

An assemblage of rocks similar to that of the Tarntal mass is seen at the Mieselkopf ridge, at a height of 2560 metres, some 9 kilometres west of the Tarntal. There is the same massive unstratified dolomite several hundred metres in depth, showing no effects of shearing or crushing, surmounted by a band of highly contorted rocks. Here the dolomite breccia, the schists, and the flaggy limestones form several distinct layers which stand at a high angle of dip (Pl. XVIII, Fig. 8, and see Map, p. 341).

The nearer view of the Mieselkopf ridge from the east conveys the suggestion of a sharp synclinal fold (Pl. XVIII, Fig. 8).

In the vicinity the tale-bearing schists are well developed, and at 2460 metres, some 200 metres below the crest, is a mottled red and green calcareous rock without foliation, much like that seen in company with ophicalcite at the serpentine contact, in the quarry at Pfons, near Matrei, some 14 kilometres to west of Tarnthal. At the site under the Mieselkopf the rock forms the core of a band of schist in the strike of one of the vertical layers of schist on the ridge. Some 50 metres higher and in the same strike is an occurrence which may throw some light on the relations between dolomite breccia and schist. Within a space of about 3 feet are some eight or ten vertical plates of dolomite breccia alternating with as many bands of the schist, which is foliated in a vertical plane parallel with the plates. Fine quartz veins traverse the dolomite in all directions, invariably stopping short of the schist which is free from veins. The phenomenon cannot be explained as a stratigraphical sequence. The dolomite breccia,

already veined with quartz, appears to have split into parallel-walled plates, between which the other rock was injected, though probably not in its present form.

A microscope section of the schist shows it to consist in great part of fine fibres of minerals of the mica, chlorite, and serpentine groups, with probably some talc, the whole woven into a felt much resembling the more fibrous specimens of the Tarntal serpentine. It contains also clusters of small grains of a carbonate, derived no doubt from the adjoining dolomite; scattered grains of quartz and orthoclase, generally without strain, shreds of a colourless mica with small axial angle ($2E = 57°$ nearly; near sericite), and a few zircons, some ilmenite and rutile, all of which might be derived from a gneissic rock; also tourmaline in minute prisms, in some cases large enough to show the interference figure of a negative uniaxal crystal in transverse sections with polygonal outline, and the higher absorption of the ordinary ray in longitudinal sections.

The schist thus represents one of the earlier intrusions of the igneous magma, the foliation being the effect of later dynamic and chemical processes which have not appreciably altered the structure of the dolomite.

This solution of the problem would make the earliest intrusion of the basic magma younger than the Tarntal dolomite, that is, later than Trias if, in accordance with generally accepted views, this breccia is to be correlated with beds of later Triassic age. The alternative assumption, viz. Tarntal breccia older than Trias, is not excluded by known facts and seems to be worth considering.

As already mentioned, the dolomite knolls of the Knappenkuchel have been referred to the Carboniferous on the ground of their resemblance to the 'Eisendolomit' of the Nösslacher Joch, where the rock is associated with grauwackes bearing impressions of *Lithodendron*, *Annularia*, *Sphenophyllum*, and other Carboniferous plants.[1] The Tarntal dolomite has occasionally the reddish tint of the Nösslach rock. All the rocks named contain some quartz.

The alternation of dolomite and schist in the Mieselkopf occurrence is too regular to have been brought about by violent movements of folding and crushing, and is probably for the main part an œcogenous character; the foliation of the schist may be due in part to mechanical causes, and is therefore possibly to some extent an apœcous character.

The talc inclusions in the fragment of Tarntal breccia already mentioned as having been found in the Upper Tarntal can be best explained as due to an injection of fluid magma such as can be seen in schists near the contact with serpentine.

The appearances indicate that the Tarntal breccia was deposited directly on the schists, after these rocks had acquired their foliated character to some extent. It is no longer feasible to treat the breccia as a 'Nappe' separate and distinct from the schists of the Reckner block. The Tarntal dolomite belonged from the first to the transported block, and was carried with it in the movement which landed the rocks in their present position. It follows that the Reckner block of

[1] Kerner, "Der Carbonflora des Steinacherjoches": *Jahrbuch der Reichsanstalt, Wien*, 1897.

FIG. 5. The scree-cone (Issl) under the Lower Tarntal.

FIG. 6. Head of the Lower Tarntal looking eastward.

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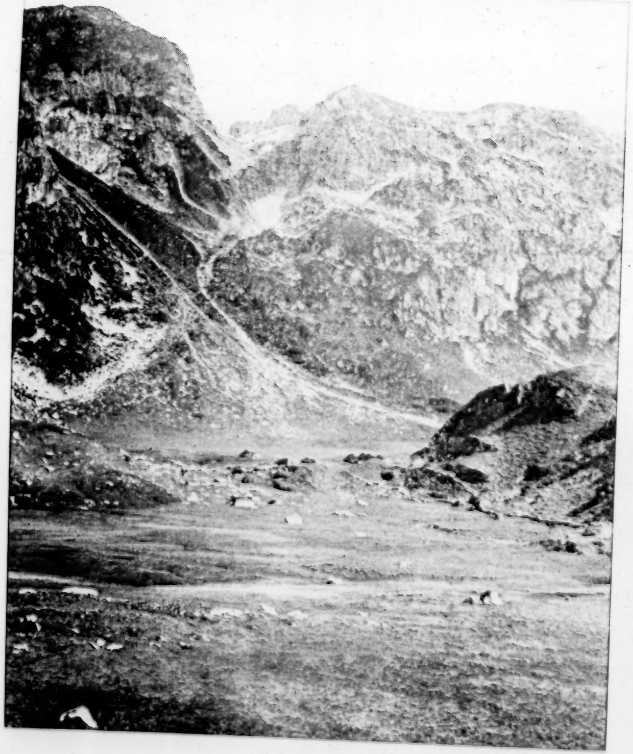


FIG. 5. The scree-cone (Iss) under the Lower Tarntal.

FIG. 6. Head of the Lower Tarntal looking eastward.

serpentine schist and dolomite is now completely inverted, but whether it is to be regarded as a simple overthrust mass or the lower limb of a recumbent fold cannot be decided on the evidence.

In the Mieselkopf occurrence the alternate plates of schist and dolomite breccia are parallel to the larger bands of dolomite seen on the ridge, from which it appears that the earlier flows of magma were guided by movements of the crust which coincided in direction with the general movement to which the present structure is due.

As regards the tectonic character, the mass of the Tarntal may be divided into two parts. The massive Triassic dolomite with Rhætic and perhaps Liassic limestones in normal position forms the lower part. This may be called the 'Knappenkuchel block'. The upper part of the mass includes the serpentine, schist, and Tarntal breccia, all probably older than the Trias and in inverted sequence. This may be called the 'Reckner block'.

Where the two masses meet is a sheared band formed partly of the upper beds of the lower block and in part of the lower beds of the upper block, approximately bands 3 and 4 of the section on p. 340.[1]

The series on p. 340 and Fig. 9, p. 339, arranged in the original sequence, would stand thus: 6 5 4 1 2 3,—6 being lowest.

## Physiography.

A conspicuous topographical feature of this mountain is the Grübl, the great cirque already mentioned. It no doubt owes its present form to ice erosion, by which the massive dolomite has been removed down to the present floor of schists. Small knolls of schist at the lip of the cirque show the well-rounded form of true *roches moutonnées*. The ice-tongue of sufficient mass to mould these knolls must have been fed by an extensive field of *firn*, and the snow-line must have stood for a considerable time at a level above the floor of the cirque, not lower probably than 2250 metres above sea, or 100 metres above the present floor. Above this level the available collecting area diminishes rapidly with the height; at 2500 metres it still includes the whole feeding-ground of the Upper and Lower Tarntal; 100 metres higher, at 2600 metres, little but the slopes of the ridges would remain. It seems, then, probable that the snow-limit at the period in question stood somewhere between 2250 and 2500 metres, or say at about 2400 metres.

We have here evidence of a resting stage during an advance or (more probably) a retreat of the ice. At the period of extreme glaciation the snow-line could not have been higher than 1800 metres, that is, it must have been at least 600 metres lower than the level attained when the 'Grübl' was excavated.

The Lower Tarntal is a straight east and west groove, the erosion of which must be due chiefly to running water. It has been beheaded by the Lizumbach, and the flow of water is now insignificant.

The Upper Tarntal is a basin-shaped hollow 80 metres above the Lower Tarntal, and has also been truncated considerably on the

[1] This modifies somewhat the hypothesis (*a*) (p. 603 of last year's paper) offered before the discovery of the Mieselkopf occurrence.

east side by the Lizumbach. It had an exit on the north-west corner over the Upper Tarntal, to which it was tributary (Pl. XVIII, Fig. 7). On the west side, nearer to the Reckner ridge, are seen earlier and higher openings, by which it drained at one time directly into the Grübl.

All the exits of Upper and Lower Tarntal are now blocked by accumulations of loose material, as seen in Pl. XVIII, Fig. 7. These cannot be due simply to falls from the overlying slopes. The débris must have been arranged by small ice-tongues which just filled the valleys, and the dams represent true end-moraines. The snow-limit at the time must have stood at 2650 metres nearly.

The present snow-limit for the nearer high mountain-masses is placed variously at 2700 to 2900 metres.

Remembering that the snow-limit is higher the greater the mass of the elevated portion of the crust, it would follow that the virtual snow-line for the small mass of the Tarntaler Köpfe is now appreciably lower than the summits (2830 to 2890 metres), but is ineffective in the absence of level surfaces capable of retaining the snow. It is probable that the high valleys have in recent times more than once borne ice-tongues, and may again be filled on the occasion of a fall in the mean annual temperature quite within the range of oscillation possible under present conditions of climate.

The Upper and Lower Tarntal contain several small lakes or ponds; there is one at the lower end of each valley just above the natural dam. The water of these ponds often carries ice till midsummer, another indication of their proximity to the present snow-line.

In this paper the term *snow-limit* has been used as equivalent to the boundary between *firn* and glacier ice. This is perhaps not strictly the case if we define the snow-line as the level above which a free horizontal surface is covered the whole year round with snow. The discrepancy does not affect the general line of reasoning.

## REFERENCES TO FIGURES ON PLATES XV–XVIII.

| Plate. | Fig. | |
|---|---|---|
| XV. | 1. | The Tarntaler Köpfe from Mucheler Alm, 4 kilometres to W.: fresh autumn snow. Compare with Fig. 9 in text, p. 339. |
| | 2. | The Tarntaler Köpfe: from the ridge of the Kreuzjöchl, distant 3 kilometres to S.W. by W. Two summits, 2836 and 2891 metres, in the middle of the picture, belong to the main mass of serpentine which shows dark against other rocks. |
| XVI. | 3. | The ridge of the Nederer, showing the strong vertical jointing; from S.S.W. |
| | 4. | Reckner (serpentine) on the right, Kahlewand (dolomite) on the left: from the serpentine peak 2836 metres to W. of Reckner. |
| XVII. | 5. | The scree-cone (Issl) under the Lower Tarntal. From the lip of the Grübl corrie. |
| | 6. | The head of the Lower Tarntal where the valley is beheaded by the Lizumbach; looking eastward. |
| XVIII. | 7. | Lake at the lower end of the Upper Tarntal, with moraine dam beyond; looking westward. |
| | 8. | The ridge to north of the Mieselkopf (2653 metres of map); looking westward. |

7

8

FIG. 7. Lake, lower end of the Upper Tarntal with moraine dam (looking west).
„ 8. Ridge north of the Mieselkopf (looking west; 2653 metres on map).

## III.—Note on the Mandible of a New Species of *Tetrabelodon* from the Loup Fork Beds of Kansas.

By C. W. Andrews, D.Sc., F.R.S., British Museum (Nat. Hist.).[1]

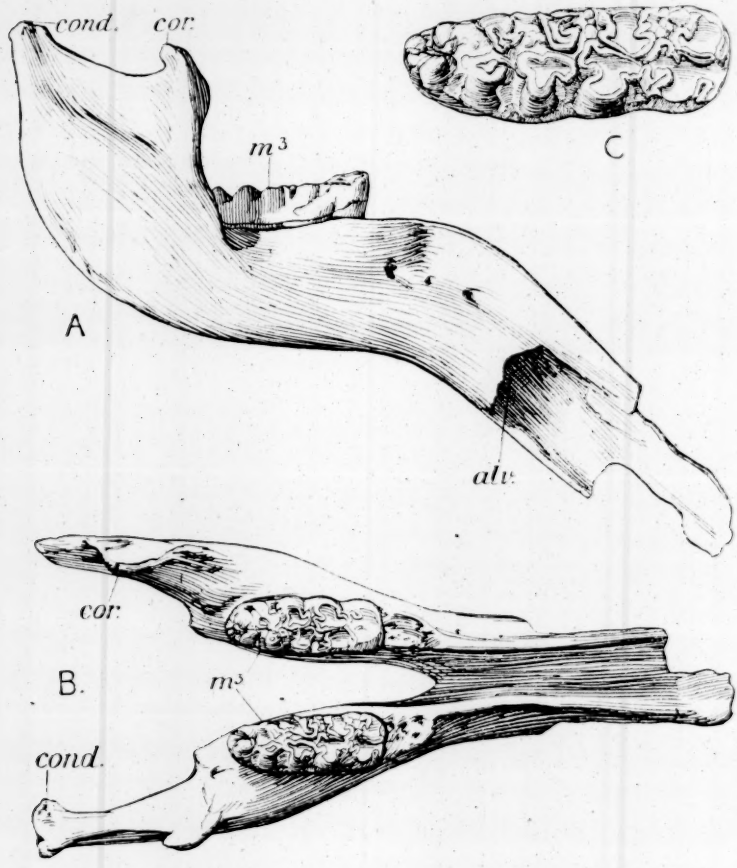
A CONSIDERABLE number of species of Tetrabelodont Mastodons are already known from various horizons and localities in the United States. Several of these from the Loup Fork deposits have been described by Cope,[2] the best known being *Tetrabelodon cuhyphodon*, *T. campester*, and *T. productus*. A fairly complete mandible recently acquired by the British Museum seems to indicate that yet another very distinct form existed contemporaneously with those just mentioned. This specimen, which forms the subject of the present note, was obtained from Mr. Sternberg, the well-known collector of fossil Vertebrates, who refers to it in his recently published work *The Life of a Fossil Hunter* (p. 123) under the name *Trilophodon campester*, Cope, from which, in spite of some similarity, I believe it to be very distinct.

The mandible, which I propose to make the type of a new species, *Tetrabelodon dinotherioides*, is from the Loup Fork Beds of North-Western Kansas. It is not quite complete, the upper portion of the ascending ramus being wanting on the left side, while on the right the articular condyle is much worn. The symphysial region also is imperfect, the outer walls of the sockets of the great lower tusks being broken away, while the extremity also is missing, the symphysis when complete probably having been considerably longer. The most striking character of this mandible is the great length and massiveness of the symphysial region (Figs. A, B), which, moreover, is deflected to a greater extent than is the case in any other *Tetrabelodon*, though considerably less so than in *Dinotherium*. The spout-like upper surface of the symphysis is narrow and deep posteriorly, its concavity being about a semicircle; in this region its alveolar edges are comparatively thin and sharp. Anteriorly this surface widens out, its concavity is less marked, and its borders become thickened and rounded. As will be seen from the figures and the table of measurements, the whole symphysial region was very massively developed, and the lower tusks, which perhaps were decurved as in *Dinotherium*, must have been very large, the vertical diameter of their roots being about 11 cm., rather greater than the width from side to side. The mandibular rami are very thick from within outwards, and are deepest just behind the symphysis. Their outer and ventral surfaces are strongly convex transversely. The ventral border is concave from before backwards just behind the symphysis, but farther back becomes strongly convex, passing into the hinder border of the ascending ramus: in fact, the whole posterior and ventral outline of the mandible seen in profile is a sigmoid curve. The condyle is not well preserved on either side; it rises about 23 cm. above the upper surface of the molars. Between the condyle and the

[1] Published by permission of the Trustees of the British Museum.

[2] Cope, "The Proboscidea"; *American Naturalist*, 1889, vol. xxiii, p. 291.

coronoid process the upper border is strongly concave; the short coronoid process, which does not rise so high as the condyle by about 4 or 5 cm., is curved strongly backwards. The anterior border of the




Mandible of *Tetrabelodon dinotherioides*, sp. nov., Andrews, from the Loup Fork Beds, North-Western Kansas.

A. Right side of mandible, $\frac{1}{12}$ nat. size.
B. Upper view of entire mandible, $\frac{1}{12}$ nat. size.
C. Upper view of third right lower molar, $\frac{1}{6}$ nat. size.

*alv.* = alveolus of tusk; *cond.* = condyle; *cor.* = coronoid process; $m^3$ = third lower molars.

Drawn from original specimen in the Geological Department, British Museum (Natural History).

ascending ramus is convex above but concave below, passing into the outer face of the horizontal ramus a little in front of the posterior end of the last molar tooth. The position formerly occupied by the

posterior end of m. 2 is indicated by a flat, roughened surface of triangular form, the anterior angle being continuous with the alveolar edges of the symphysial groove. There are three nutritive foramina on the outer surface of the jaw. They are separated by nearly equal intervals of about 5·5 cm., and the hindermost is about opposite the hinder end of the symphysis.

Of the teeth, the incisors have been entirely lost and the last molars alone remain, the second having been already shed before the death of the animal. The last molars are in a not very advanced state of wear, the posterior lobes being as yet untouched. Each (Fig. C) consists of four transverse ridges and a posterior lobe. Each ridge is composed of an outer and an inner portion distinctly separated. The outer tubercles give a trefoil pattern in wear, while the inner are imperfectly divided into an inner and an outer portion. There is a tendency to the alternation of the outer and inner portions of the ridges, the inner tubercle being situated opposite the anterior lobe of the outer trefoil, the posterior lobe of which almost blocks the transverse valley. There are also some small accessory tubercles in the valleys. The posterior lobe of the tooth consists of an inner and an outer tubercle and a cusp, imperfectly divided into two, forming the extreme posterior angle of the crown. The cingulum is developed on the outer side of the tooth, opposite the openings of the transverse valleys. The whole crown is very low, but at the same time it seems to have been thickly covered with cement, which nearly fills the valleys. The specimen described above appears to indicate the existence of a species widely different from those previously described from this horizon. The only forms with which it might be compared are *Tetrabelodon euhyphodon*, *T. campester*, and *T. proavus* of Cope. From the former of these it is distinguished by the much greater deflection of its symphysial region and the larger number of ridges in its last lower molar. *T. campester* has a much more slender and less deflected symphysial region. In *T. proavus* also, judging from Cope's figure, although the symphysis is more massive than in *T. campester*, it is much less bent down than in the present species, and the whole jaw seems to be more slender.

The dimensions of this specimen are—

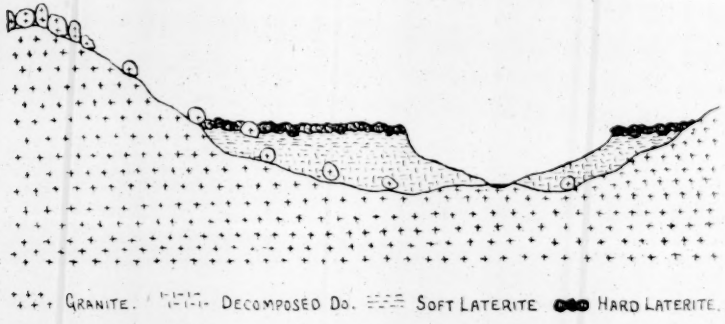
| | | cm. |
|---|---|---|
| Length from condyle to tip of symphysis | (approx.) | 126·5 |
| Length from posterior end of m. 3 to tip of symphysis | | 93·5 |
| Length of symphysis | | 63·6 |
| Width of ascending process | (approx.) | 27·0 |
| Width between condyle and tip of coronoid process | | 22·5 |
| Depth of symphysis at hinder end | | 21·0 |
| Vertical diameter of socket of tusk | (approx.) | 11·0 |
| Transverse diameter of socket of tusk | (approx.) | 7·5 |
| Depth of mandibular ramus at symphysis | | 21·0 |
| Depth of mandibular ramus opposite anterior edge of ascending process | | 16·0 |
| Thickness of mandibular ramus beneath m. 3 | | 16·0 |
| Depth of concavity of upper surface of the hinder end of the symphysis | | 5·0 |
| Width of concavity of upper surface of the hinder end of the symphysis | | 7·5 |
| Width between the posterior ends of the molars | (approx.) | 18·0 |
| Length of last lower molar | | 24·0 |
| Width of last lower molar | | 8·7 |

## IV.—Notes on Rhodesian Laterite.

By F. P. Mennell, F.G.S.

A NUMBER of communications dealing with the origin and composition of the material commonly known as laterite have appeared in the Geological Magazine during the past few years. That of Dr. Maclaren[1] is an especially valuable contribution to the literature of the subject, and I think few workers in the Tropics will be disposed to question the substantial accuracy of his conclusions. I shall not attempt, therefore, to discuss the general problem presented by the widespread occurrence of laterite deposits in tropical regions. The object of the present brief communication is merely to place on record a few observations made in another area.

*Conditions of Formation.*—Mr. J. R. Kilroe in his interesting communication regarding the German bauxites seems inclined to question the necessity of tropical conditions for the accumulation of laterite. He states[2] that on this supposition laterite should be met with everywhere throughout the Tropics. As a matter of fact, it is. In Rhodesia, for instance, it is by far the most abundant superficial deposit. It may be pointed out, however, that it is not tropical heat which is the essential condition, but the alternation of perfectly distinct wet and dry seasons, which is only observed in or near the Tropics. In Bulawayo (20° S. lat.), for example, we have in an ordinary season about 25 inches of rain, which falls in the summer months, say from about the middle of October to the middle of April.




Sketch to illustrate a common mode of occurrence of Laterite.

There may be occasional showers in September or May, but as a general rule June, July, and August are absolutely rainless. Usually, indeed, there is no rain whatever between the end of April and the end of September. Over most of Rhodesia the rainfall is heavier than near Bulawayo, but precisely similar conditions prevail. Scattered over the country, therefore, we find considerable tracts (chiefly on the granite) which are distinctly marshy during the rainy season, but dry up completely when the wet weather comes to a close. Thus among the Matopo Hills there are a number of valleys which may usually be

[1] Geol. Mag., 1906, pp. 536–47. [2] Op. cit., 1908, p. 539.

regarded as swamp from November to March, though many of them are quite dry for the rest of the year. It is, of course, difficult to ascertain the nature of the changes going on beneath the surface of the soil in a present-day swamp, though by digging in the dry season I have found that deposits of a lateritic nature were disclosed at a depth of a couple of feet under the soil. This last is always somewhat peaty, so that there must be abundance of carbonic acid, and possibly other stronger acids of organic origin, to aid in the chemical changes to which the production of laterite is due.

*Mode of Occurrence.*—The most conspicuous occurrences of laterite are those in which it may be seen lying about all over the surface or showing up through the soil in large blocks. These are due, of course, to changes in the physical geography of marshy tracts. Erosion along a particular line of drainage has led to the formation of a well-defined channel which has drained the swamp and incidentally carried off most of the soil which originally concealed the laterite. There are some very interesting cañon-like valleys cutting through the comparatively level ground between some of the lines of hills in the Matopos, e.g. to the north of Mount Impu. These little cañons are usually about 15 to 30 feet deep, with almost vertical sides, which they owe to the crust of hard laterite overlying the softer material and decomposed granite in which the streams have cut their channels. When the hard bed-rock is reached the process of widening the valleys becomes inevitable, and accordingly most deposits of laterite occur as a capping to terraces on either side of a valley. The slope of these terraces is sometimes considerable. This is not due to erosion, but to the curious feature shown by so many swamps in this country (Rhodesia), of occurring on sloping instead of on level ground. Some of the Matopo swamps which show standing water everywhere have quite a considerable inclination.

The section given shows the general mode of occurrence that we have described. It is based on a sketch made about 10 miles south-east of the World's View in the Matopos.

*Underlying Rocks.*—It is perhaps well to emphasize the fact that the accumulation of laterite does not appear to be dependent to any extent on the nature of the underlying rocks. Mr. Kilroe does not seem to realize this important fact; indeed, the idea seems prevalent that basalt or dolerite is the general source, though it may be noted that Dr. Maclaren's figured example[1] is stated as overlying quartz-biotite-schist. Laterite occurs, to my personal knowledge, in Rhodesia, resting on nearly every possible description of rock. The following may be cited, the locality of one such occurrence being given in brackets in each case:—

*Sedimentary:* Gravel (Somabula).
Sandstone (North of Gwelo).
Limestone (Gwanda).

*Igneous:* Granite (Matopos).
Basalt (Shiloh).
Picrite (Selukwe).

[1] Geol. Mag., 1906, p. 538.

*Metamorphic:* Hornblende-schist (Bulawayo).
Chlorite-schist (Gatooma).
Schistose Serpentine (Sebakwe).
'Banded Ironstone' (Hopefountain).

As regards the sediments cited in the two first instances, the laterite may perhaps be regarded as of detrital origin, at least in part. In all the other instances it is due to the decomposition *in situ* of the underlying rocks, whose nature is reflected in the constitution of the resulting laterite.

*Composition.*—The commercial importance attaching to the highly aluminous varieties of laterite has led to their being given much prominence in discussing its origin, and perhaps rather obscured the fact that such deposits are of limited extent. The ordinary forms of laterite are usually more or less conglomeratic, owing to the inclusion of abundant fragments of vein-quartz and of the underlying rocks, as well as drifted sand, etc. The following determinations of the more important constituents of three Rhodesian samples of laterite will serve to illustrate this point.

| | *A.* | *B.* | *C.* |
|---|---|---|---|
| Iron oxide, $Fe_2O_3$ . . | 14·71 | 32·14 | 34·8 |
| Alumina, $Al_2O_3$ . . . | 1·41 | ·22 | 25·9 |
| Combined water, $H_2O$ . | 4·44 | 6·37 | not det. |
| Insoluble (+silica) . . | 75·10 | 60·69 | 29·2 |

*A* represents a light-coloured laterite resting on granite, from the Matopos; *B* a dark-coloured sandy laterite resting on hornblende-schist, near Bulawayo. Both of these were average bulk samples collected by the writer, in which the iron and alumina were first separately determined by the caustic alkali method and then checked by titration of the iron. *C* represents a reddish laterite from Northern Rhodesia presented to the Rhodesia Museum by Mr. L. Ludlow.

*A* and *B* probably represent the average composition of normal laterite much more nearly than most published analyses. As regards more exceptional varieties, very little investigation would probably reveal much more aluminous types than *C*. Some of the laterites from the Victoria Falls region are known to be very rich in iron, almost pure limonite, in fact. Although the underlying rock is basalt, they are very free, as a rule, from alumina. Some of the Somabula laterite contains a great deal of manganese, and must approximate in composition to wad.

## V.—On some Fossils from the Nubian Sandstone Series of Egypt.[1]

By R. Bullen Newton, F.G.S.

(WITH A MAP, PLATE XIX.[2])

### Introduction.

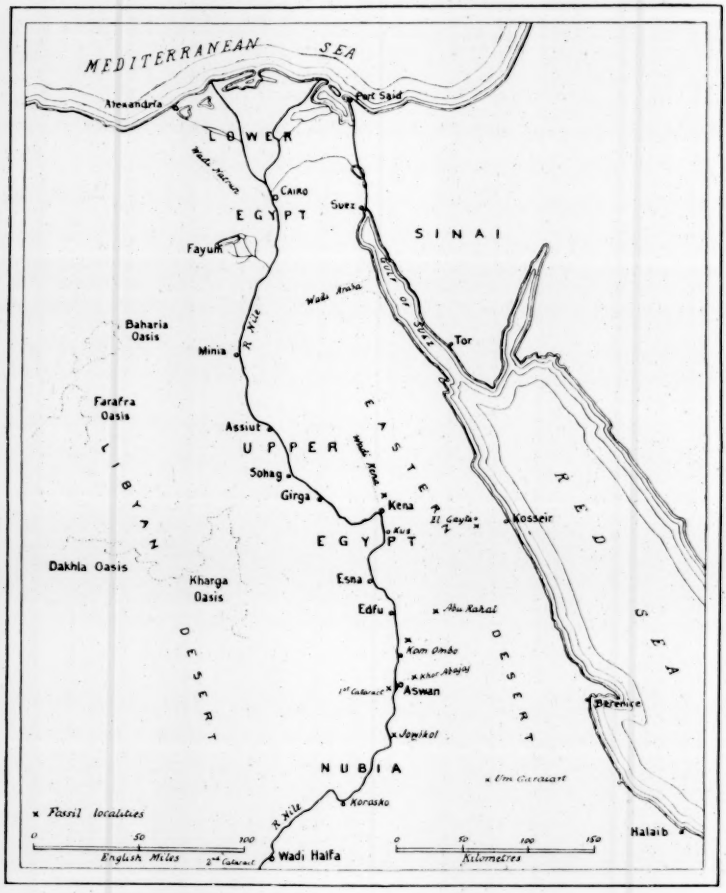
DR. W. F. HUME, Superintendent of the Geological Survey of Egypt, has recently sent to the Geological Department of the British Museum, for determination and report, a few Pelecypod shells

[1] Published by permission of the Trustees of the British Museum.

[2] Plates XX and XXI, giving figures of the fossils, will appear with the concluding part of the author's paper in September.

SKETCH-MAP OF EGYPT

*Showing localities whence fossils have been obtained from the Nubian Sandstone*



of fluviatile origin, directly associated with the marine genus *Galeolaria*, which he, in company with his colleagues Messrs. Crosthwaite and Murray, lately discovered in the ferruginous beds of the Nubian Sandstone Series of Southern Egypt.

As well as placing on record an account of these fossils, this paper includes the description of a remarkably fine example of an *Inoceramus* which Dr. John Ball, of the same Survey, discovered a few years since in another area of Southern Egypt, and in an exactly similar ferruginous deposit of the Nubian Sandstone formation.

The particular locality of the freshwater shells and the annelid tubes is given by Dr. Hume as Jowikol, situated on the east bank of the Nile, 19½ kilometres north of Kalabsha Temple and 40 kilometres south of Aswan. He writes: "The height of the fossil bed above Jowikol was approximately 137 metres above mean sea-level, or about 40 metres above the Nile. No granite was noted on this bank, the nearest outcrop on the east side being a granite range 5 kilometres to the east." The rock is highly ferruginous, of reddish-brown colour, and is distinctly a limonite, showing sometimes a minutely pisolitic structure. Remarking on this formation, Dr. Hume states: "The Nubian Sandstone often contains these hard ferruginous layers, but the greater part of the beds in this neighbourhood are fine-grained sandstones or fine-grained sandy clays."

Dr. Ball obtained his *Inoceramus* from the west end of the Aswan Dam during excavations for a small reservoir, at a height of not more than 20 metres above the old igneous rocks and a somewhat similar height above the Nile. The matrix surrounding this specimen is exactly similar to the Jowikol rock, although some 40 kilometres separate these two regions of the Nile Valley. The rarity of fossil remains in this formation adds an interest to the present specimens, especially as their characters appear to suggest a more definite age for this part of the Nubian Sandstone than has hitherto been acknowledged.

In concluding the preliminary statement the writer wishes to thank both Dr. Hume and Dr. Ball for the interest they have shown in the compilation of this paper. The former has supplied every fact of importance concerning the locality and geology in connexion with his discovery of the *Serpula* and fluviatile mollusca, whilst the latter has been good enough during his vacation in England to furnish information concerning the specimen of *Inoceramus*, as well as to prepare a sketch-map of Egypt including most of the localities referred to in the paper, the reproduction of which as one of the plates it is thought will add a greater interest to this contribution (see Map, Plate XIX).

## Bibliography (restricted).

Without entering into the many problems connected with the history of the Nubian Sandstone, it may be of interest to briefly review some of the previous opinions on this subject, but only those having a bearing on the formation as it occurs in Southern Egypt and Nubia itself.

Joseph Russegger[1] was apparently the first geologist to recognize these rocks as the Nubian Sandstone—'Nubischer Sandstein.' He found it underlying the Cretaceous beds of Southern Egypt (Edfu, Aswan, and Kalabsha) and Northern Nubia (Korosko, etc.), associated with concretionary iron sandstone and brown ironstone, and with no evidence of fossils throughout its development. He regarded its age as Triassic and comparable to the European Keuper.

Lefévre,[2] another of the early students of this formation, ascribed its origin to the Cretaceous period, from an examination of the sandstone at Aswan (=Syène). Ehrenberg[3] came to similar conclusions after surveying the same area. He found that the "limestone is incumbent on sandstone—Quadersandstein?—and the two repose on granite and the primary rocks connected therewith".

The first mention of fossils in the Nubian Sandstone was made by Russegger,[4] who recorded the occurrence of dicotyledonous stems and a *Cyclas* from near Aswan, his statement being as follows: "In diesem Sandsteine der mit bunten Thonstraten wechselt, fand ich eine *Cyklas* (Faba, Münster? Steinkern mit einem kleinen Theil der aufsitzenden Schale), die einzige Versteinerung, die ich ausser Dikotyledonenstämmen in diesem Sandsteine in ganz Egypten und Nubia zu finden Gelegenheit hatte." On this occasion the author resigned his previous views of a Triassic age for this formation and determined it as Cretaceous—"Grünsandstein, Quadersandstein, Wealderthon." He also correlated the Sinaitic Sandstones with those of Lower and Upper Egypt and Nubia, and afterwards set out such results in tabular arrangement, which was published in a later volume of his *Reisen*.[5] The sandstone beds at Kalabsha were described as being horizontal.

According to Newbold's work on *The Geology of Egypt*,[6] only coniferous woods were found in the Nubian desert, whilst the silicified woods of the Egyptian desert were dicotyledonous. Newbold was, however, unable to fix the geological position of the sandstone formation.

In his geological description of the first cataract of Egypt, J. C. Hawkshaw[7] referred to the crystalline rocks forming the bed of the Nile being overlain on both banks by a sandstone of variable consistency and frequently impregnated with iron. He also observed that the sandstone contained "no vestige of organic remains, unless some of the nodules and concretions of ironstone can be regarded as indicative of such, as many of these appear at first sight to be the actual casts of shells".

It was Lartet's[8] opinion that the Nubian Sandstone should be

[1] Neues Jahrb., 1837, pp. 665–9; ibid., 1838, p. 630; ibid., 1840, p. 57. Bull. Soc. Géol. France, 1839, vol. x, pp. 234–9.

[2] Bull. Soc. Géol. France, 1839, vol. x, p. 144.

[3] London, Edinburgh, Dublin Phil. Mag., 1841, vol. xviii, p. 394.

[4] *Reisen in Europa, Asien, und Afrika* (Stuttgart, 1843), vol. ii, pt. i, pp. 276, 306, 314, 330, 570, 575.

[5] 1847, vol. iii, pp. 285–9.

[6] Quart. Journ. Geol. Soc., 1848, vol. iv, pp. 324–57. (An abstract of this paper was published in the Proc. Geol. Soc. London, 1842, vol. iii, pp. 785, 786.)

[7] Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 115–19, with geological sketch-map.

[8] Bull. Soc. Géol. France, 1868, ser. II, vol. xxv, p. 490.

correlated with similar rock formations of Algeria, Sinai, Syria, Arabia, and India (Bagh), and so be regarded as Middle Cretaceous or Cenomanian. Lartet found that no intrusions were observable from the underlying igneous rocks.

Bauerman[1] determined the sandstones of Arabia Petræa as similar to those of Egypt and Nubia, having older crystalline rocks below and undoubted Cretaceous above. He thought such beds were of Triassic age.

Ralph Tate's[2] remarks *On the Age of the Nubian Sandstone* are interesting, because a part of the formation in the Sinaitic region was recognized as Carboniferous from the fossils that were found in the associated limestones (*Orthis Michelini*, etc.), whilst the sandstone had yielded impressions of *Lepidodendron* and *Sigillaria*. Tate, likewise, referred to Unger's[3] determination of *Dadoxylon Ægyptiacum* (=coniferous) from the sandstone of Aswan and Um-Ombos of the Nile Valley, which he regarded as contemporaneous in age with the *Lepidodendron*[4] and *Sigillaria*[5] from the Sinaitic region.

In remarking upon the Red Sandstone of Nubia, Coquand[6] called attention to the discovery by Delanoue of *Ostrea Verneuili* of Leymerie, in a boring called 'El-Aoui' (since localized by Zittel as probably in the Wadi Ouh, south-east of Edfu), through 94 metres of 'Grès nubiens', which he considered proved the Garumnian age (= Upper Cretaceous) of that formation.

M. Pomel[7] would not recognize the Garumnian age of the sandstone advocated by Coquand. He regarded the sandstones of Central Sahara as chiefly Devonian, of Sinai and Nubia (the true Nubian Sandstone) as Carboniferous and extending into Abyssinia, Western Guinea as probably Corallian, and of Palestine and Western Barbary as Lower Cretaceous or about the horizon of the Neocomian or Gault.

The *Libyschen Wüste* by Zittel[8] treats very fully of the Nubian Sandstone. He places it in the Senonian group, and refers to *Mosasaurus* (*M. Mosensis*) remains having been found by Figari Bey at a depth of 400 feet in a boring in the valley of Kena in 'Aschgrauen Thon', similar to rocks occurring at Wadi Ouh, a large turtle carapace being also discovered on the same occasion.

The occurrence of *Dadoxylon* in Southern Egypt induced Dawson[9] to regard the Nubian Sandstone of that area as Palæozoic rather than Mesozoic, although he was of opinion that both in Southern Egypt and Sinai there was probably an Upper Palæozoic Sandstone supporting a not dissimilar sandstone of Lower Cretaceous age. Dawson also noted, in a section between Kom Ombos and Aswan, the occurrence of two distinct beds in the Nubian Sandstone, the upper consisting of a ferruginous irregular sandstone, the lower being grey and laminated.

[1] Quart. Journ. Geol. Soc., 1869, vol. xxvii, pp. 17–38.
[2] Quart. Journ. Geol. Soc., 1871, vol. xxvii, pp. 404–6.
[3] Sitzungsb. Akad. Wiss. (Wien), 1859, vol. xxxiii, p. 228, pl. i, figs. 3–5.
[4] Salter, Quart. Journ. Geol. Soc., 1868, vol. xxiv, p. 509.
[5] Holland, Quart. Journ. Geol. Soc., 1866, vol. xxii, p. 492.
[6] Bull. Soc. Géol. France, 1876, ser. III, vol. iv, pp. 159, 160.
[7] Ibid., pp. 524–9.
[8] *Palæontographica*, 1883, vol. xxx, pp. 59, 76, 77, 93.
[9] Geol. Mag., 1884, pp. 391–3.

In connexion with the geology of Wadi Arabah, Professor Schweinfurth[1] referred to the absence of fossils in the Nubian Sandstone (with the exception of silicified wood) as follows: "C'est en vain que certains voyageurs ont essayé de convaincre le monde géologique qu'ils avaient eux-mêmes détaché des pétrifications de ce grès." He further remarks that we often mistake sandstone-looking rocks, which represent in Egypt the lower stage of the Upper Chalk and which are rich in fossils, for the true Nubian Sandstone, which pass insensibly into them.

Professor Walther[2] originated the theory that the so-called 'Nubischer Sandstein' was an æolian dune formation which pointed to the existence of Palæozoic and Mesozoic deserts in Northern Africa.

An iron-ore deposit in the neighbourhood of Wadi Halfa has been described by Captain Lyons[3] as part of the Nubian Sandstone Series. It occurs in lenticular bands, and is usually of strongly oolitic structure containing fragmentary fossil wood, but, so far as his observations extended, without any other organic remains. The Nubian Sandstone was considered of estuarine origin, and not formed in the waters of a vast inland lake as maintained by Professor Edward Hull.[4] Captain Lyons was further of opinion that the sandstone of the Libyan area was Cretaceous, whilst that of the eastern parts of Egypt, Sinai, and Palestine was deposited during Carboniferous times.

When writing upon the geology of the Nile Valley, Professor Hull[5] stated that he had examined parts of the Nubian Sandstone of that area and had found it to be very unlike in mineral character to that of Cretaceous age in Arabia Petræa and the Arabah Valley, but he did not on that account think that such data were sufficient for regarding these distant deposits as of different geological ages.

Remarking further upon this subject, Captain Lyons[6] observed that the Nubian Sandstone to the south-east of Korosko (Nubia) "is laid down on the flanks of the crystalline hills, with little or no dip". It is of quartzose composition of variable colour—yellow, brown, and red, from staining by oxides of iron and manganese. Sometimes a more argillaceous bed is present, but this is not constant. No rock intrusion of the sandstone was observable.

In his extended account of this formation, Dr. Blanckenhorn[7] mentions Russegger's discovery of the shell-cast near Aswan, which was said to resemble *Cyclas faba* of the Wealden formation. He does not favour the Garumnian age of the sandstone as advocated by Coquand. In a correlation scheme of the Cretaceous formations of Egypt he regards the Nubian Sandstone of the Libyan Desert as Campanian, that of the Nile Valley and southern parts of the Arabian Desert as Santonian, and the northern parts of the Arabian Desert as

[1] Bull. Instit. Égyptien, 1888, ser. II, No. 8, p. 156.
[2] Verhandl. Ges. Erdkunde, Berlin, 1888, vol. xv, p. 253.
[3] Quart. Journ. Geol. Soc., 1894, vol. l, pp. 531–47.
[4] Trans. Victoria Institute, 1890, vol. xxiv, p. 317.
[5] Quart. Journ. Geol. Soc., 1896, vol. lii, p. 311.
[6] Quart. Journ. Geol. Soc., 1897, vol. liii, p. 362, with sketch-map showing distribution of sandstone in that area.
[7] Zeitsch. Deutsch. Geol. Ges., 1900, p. 31.

Cenomanian. He quotes *Ostrea Boucheroni* (?) and *Mosasaurus*, as occurring in the Nubian Sandstone of Kena in the Nile Valley, as being of Santonian age; and from El Gayta, about 40 kilometres east of Kus, in the southern half of the Eastern or Arabian Desert, he identified *Ostrea Boucheroni* and *O. Bourguignati* as Nubian Sandstone fossils belonging to the Santonian; whilst the siliceous wood stems, known as *Araucarioxylon Ægyptiacum* and *Nicolia Ægyptiaca*, are recognized as being of Campanian age.

In connexion with their survey of the central portion of the Eastern Desert of Egypt, Messrs. Barron & Hume[1] state that east of Kena the softer beds of the sandstone near the summit have yielded a vertebra of *Mosasaurus*. These authors agree with previous opinions, that the Nubian Sandstone has been laid down on an eroded surface of an old igneous region.

Dr. John Ball,[2] in his report on Jebel Garra and the Oasis of Kurkur, referred to the Nubian Sandstone as follows: "With the exception of silicified wood and a single badly-preserved gastropod (*Natica* sp.), no fossils were found by the author in the sandstone of Lower Nubia, but the position of the beds, where overlain by other rocks near Jebel Garra, is such as to leave no doubt of their Cretaceous age."

A further study of this formation by Dr. Hume[3] in the Peninsula of Sinai enabled him to recognize it as probably a marine deposit on account of the coarse conglomerates at its base and the rare occurrence of marine shells in it, referring in this connexion to Dr. Ball's recent discovery of *Inoceramus Cripsi* near Aswan, which had been determined by Dr. Blanckenhorn.

In his memoir on the geology of the Aswan district of the Nile Valley, Dr. Ball[4] acknowledges that the age of the Nubian Sandstone has been a frequent subject of controversy. He mentioned that some similar sandstones of Sinai are Carboniferous, whereas those of the Oases and Nubia itself are Cretaceous. His discovery of *Inoceramus Cripsi*, as determined by Dr. Blanckenhorn, in the sandstone beds close to the west end of the reservoir dam at Aswan, is also referred to.

Again, in the Eastern Desert of Egypt Dr. Hume[5] gathered some valuable information on the Nubian Sandstone Series and some fossils in connexion therewith. He referred to a fossiliferous shale occurring at Abu Rahal, 40 kilometres east of Edfu, at a depth of over 50 metres (a well boring), containing carbonized plant-remains, numerous examples of a *Lingula*, a mytiloid shell, *Septifer* cf. *lineatus* of J. de C. Sowerby, sp., as well as a Ganoid scale: "the aspect of the fauna being thus markedly Cretaceous." Further on in the same report Dr. Hume mentioned the discovery of fern-fragments in the Nubian Sandstone to the north-west of Um Garaiart, in the Wadi Alagi, by Mr. Charteris Stewart, which, according to Professor

[1] *Notes on the Geology of the Eastern Desert of Egypt* (London, 1902), pp. 172, 181, 200.
[2] Survey Department, Public Works Ministry, Egypt (Cairo, 1902), pp. 25–9.
[3] Survey Department, Egypt (Cairo, 1906), pp. 152, 153.
[4] Survey Department, Egypt (Cairo, 1907), p. 67.
[5] Survey Department, Paper No. 1 (Cairo, 1907), pp. 29, 32, footnotes.

Seward,[1] exhibited strong resemblances to the Carboniferous *Pecopteris* and the Wealden *Weichselia*. The results of a further study of this plant enabled Professor Seward to recognize it as part of a frond of *Weichselia*, and although, with considerable hesitation, he was inclined to regard it as of Wealden age, he was aware that no great weight should be attached to such an opinion. The same expert described another fern (in the same paper) from the Nubian Sandstone, found by Mr. H. T. Ferrar east of Edfu, between Wadi Dum and Wadi Abbad, as *Clathropteris Egyptiaca*, n.sp. In connexion with this it is stated that "such evidence as the fragment affords is primarily in favour of Rhætic or Lower Jurassic age", an opinion, however, which is mentioned as being contrary to that of Dr. Hume, who regards the sandstone in which the specimen was found as Upper Cretaceous.

It will be convenient now to tabulate the fossils from the Nubian Sandstone Series of Southern Egypt and Nubia, which have been briefly referred to in the foregoing review of published notices on this subject.

## RECORDED FOSSILS FROM THE NUBIAN SANDSTONE OF SOUTHERN EGYPT AND NUBIA.

(The authorities for horizons are placed in square brackets.)

### REPTILIA.

Mosasaurus Mosensis, Zittel MS. (=list name).

*Horizon.*—Senonian [Zittel; Barron & Hume].

*Locality.*—Kena Valley (boring 400 feet depth).

### PISCES.

(Ganoid scale.)

*Horizon.*—Cretaceous, shales in Nubian Sandstone Series [Hume].

*Locality.*—Abu Rahal, 40 kilometres east of Edfu (well boring 50 metres = 164 feet depth).

### PELECYPODA (= Lamellibranchiata).

Cyclas faba, ? Münster (accompanied by dicotyledonous stems).

*Horizon.*—"Grünsandstein, Quadersandstein, und Wealderthon" [Russegger].

*Locality.*—Near Aswan.

Inoceramus Cripsi, Blanckenhorn MS., *non* Goldfuss *nec* Mantell.

*Horizon.*—Senonian (Campanian) [Blanckenhorn].

*Locality.*—Aswan, reported by Hume and Ball.

Ostrea Bourguignati, Coquand.

*Horizon.*—Senonian (Santonian) [Blanckenhorn].

*Locality.*—El Gayta, about 40 kilometres east of Kus, in the southern half of the Eastern Desert.

Ostrea Bouchéroni (?), Coquand.

*Horizon.*—Senonian (Santonian) [Blanckenhorn].

*Locality.*—Kena, Nile Valley; El Gayta, about 40 kilometres east of Kus, in the southern half of the Eastern Desert.

Ostrea Verneuili, Leymerie.

*Horizon.*—Danian (Garumnian) [Coquand].

*Locality.*—'El-Aoui,' probably in the Wadi Ouh, south-east of Edfu (well boring 94 metres = 308 feet depth).

[1] Geol. Mag., 1907, pp. 253–7, with woodcut figures.

Septifer cf. lineatus, J. de C. Sowerby, sp.

*Horizon.*—Cretaceous (shales) [Hume].

*Locality.*—Abu Rahal, 40 kilometres east of Edfu (well boring 50 metres = 164 feet depth).

BRACHIOPODA.

Lingula sp.

*Horizon.*—Cretaceous (shales) [Hume].

*Locality.*—Abu Rahal, 40 kilometres east of Edfu (well boring 50 metres depth).

PLANTÆ.

Araucarioxylon (Dadoxylon) Ægyptiacum (Krauss), Unger.

*Horizon.*—Senonian (Campanian) [Blanckenhorn].

*Locality.*—Aswan and Um-Ombos (= Kom Ombo), between Aswan and Edfu; Dakhla Oasis (recorded by Schenk in Zittel).

Nicolia Ægyptiaca, Unger.

*Horizon.*—Senonian (Campanian) [Blanckenhorn].

*Locality.*—Libyan Desert (east of Regenfeld; see Zittel).

Weichselia sp. (= Fern).

*Horizon.*—Wealden [Seward].

*Locality.*—North-west of Um Garaiart, Wadi Alagi, Northern Nubia (about 70 kilometres eastward of the Nile).

Clathropteris Egyptiaca, Seward (= Fern).

*Horizon.*—Lower Jurassic [Seward]; Upper Cretaceous [Hume].

*Locality.*—Between Wadi Dum and Wadi Abbad, east of Edfu.

(*To be concluded in our next Number.*)

## VI.—Geology and Petrology of the Intrusions of the Kilsyth-Croy District, Dumbartonshire.

By G. W. Tyrrell, A.R.C.Sc., Assistant in Geology, Glasgow University.

(*Concluded from the July Number, p.* 309.)

### V. Mutual Relations and Order of Crystallization of the Essential Constituents.

The general appearance of this rock in thin section is of an interlocking framework of plagioclase, augite, and iron-ores, with micropegmatite occupying the interstices. The mutual relations of the felspar and augite vary considerably. The felspar may be entirely enclosed in the augite. In this case it is very basic and only faintly zoned. The most common relation is for the augite to enclose the terminations of the felspar laths, the sub-ophitic structure of Watts.[1] But frequently idiomorphic crystals of augite are found partly or wholly enclosed in felspar. The latter is then more acid than the ophitic felspar, and is broadly zoned. These varying relations may frequently be found within the limits of a single slide.

These facts may be completely explained on the hypothesis that felspar substance separated from the magma during practically the whole process of crystallization; whilst the separation of the pyroxenes was episodal, beginning after the first separation of felspar, thus enclosing some of the earlier basic crystals, and ending before the complete separation of the later, more acid felspars. The latter were therefore

[1] *Ancient Volcanoes of Great Britain*, vol. i, p. 417.

able partly or wholly to enclose crystals of augite. There is no evidence of two separate generations of felspar. The crystallization of the felspar was a perfectly continuous process, the composition varying from labradorite at the beginning to acid oligoclase at the end.

The earlier felspars, augite, and iron-ores are perfectly idiomorphic towards the micropegmatitic ground-mass, but the later felspars, as explained above, appear to be continuous with the felspar of the micropegmatite. This is specially noticeable in the coarser varieties. The micropegmatite is in all probability the eutectic mother-liquor left after the separation of the more basic elements.[1] In an instructive study of similar rocks from India, Sir Thomas Holland has suggested that in a large boss, where the separation of the basic element is comparatively small, the mother-liquor may crystallize as a large body of granophyre. He would thus explain the frequent association of gabbro and granophyre.[2] It would also go far to explain the frequently puzzling and contradictory relations of these two rocks, which in the case of Skye led several careful observers to take conflicting views as to which of the rocks was intrusive in the other.

### *The Acid Veins.*

A thin section of an inch vein from Colzium Quarry, Kilsyth, shows under the microscope an apparently homogeneous mass of kaolinized felspars, with minute grains of quartz, diversified by a few sporadic crystals of augite, many ragged flecks of a deep-green chlorite, and small skeleton-crystals of ilmenite. Between crossed nicols the rock is seen to consist essentially of an interlocking aggregate of small, stumpy felspars, highly altered, but still showing lamellar twinning. The decomposed condition of the crystals prevents a determination of the extinction angle, but by the application of the Becke method to small areas of comparatively unaltered felspar in contact with balsam, it can be shown that the refractive index is lower than that of balsam. The felspar therefore in all probability belongs to albite. This is in accord with the results of Elsden and Falconer on the similar rocks of St. Davids and Bathgate Hills respectively. These veins are similar to many aplites and microgranites. Petrographically they are soda-aplites or soda-microgranites. In the larger veins quartz and micropegmatite are rare, but with a decrease in the width of the veins there is a corresponding increase in the proportion of these constituents, and the rock becomes more and more like the intersertal material in the diabase.

### *The Contact Rocks.*

Towards the margin the structure becomes more and more ophitic, the felspars become more lathy, the proportion of iron-ore increases, micropegmatite and quartz dwindle and disappear, and the rock finally takes on a thoroughly basaltic structure. The felspar, however, remains of the same species—medium labradorite—as in the coarser rocks, and the increasing basicity towards the margin must be

[1] Teall, *Brit. Petrog.*, 1888, p. 401.
[2] Holland, Q.J.G.S., 1897, vol. liii, pp. 412–14.

attributed to an increase in the proportion of the femic constituents. At the actual margin spherulitic and tachylytic structures sometimes occur, and where in contact with carbonaceous strata the rock suffers the endomorphic metamorphism resulting in the production of 'white trap'.

A slide from a specimen taken from the lower margin of the great Sauchie sill near Stirling shows sparse but uniformly scattered felspar microlites in a greyish cryptocrystalline ground-mass, with numerous small grating-like skeletal crystals of ilmenite. There are interspersed numerous small microporphyritic groups of fresh lathy plagioclase. Here and there are small corroded xenocrysts of quartz.

## VI. The Chemical Composition.

Mr. D. P. Macdonald, M.A., B.Sc., Baxter Demonstrator in Geology at Glasgow University, has kindly made me a complete analysis of the normal type from the Auchinstarry Quarry, Kilsyth.

The result is given in Table I, col. I, below—

TABLE I.

| | I. | II. | III. | IV. |
|---|---|---|---|---|
| $SiO_2$ . | 49·80 | 50·71 | 48·62 | 50·55 |
| $TiO_2$ . | 1·56 | 1·92 | 3·36 | 1·58 |
| $Al_2O_3$ . | 17·77 | 14·78 | 13·03 | 15·00 |
| $Fe_2O_3$ . | 2·29 | 3·52 | 2·11 | 2·54 |
| $FeO$ . | 8·75 | 8·95 | 9·99 | 7·90 |
| $MnO$ . | tr. | ·31 | tr. | — |
| $MgO$ . | 5·67 | 5·90 | 4·21 | 6·25 |
| $CaO$ . | 8·85 | 8·21 | 9·77 | 7·85 |
| $K_2O$ . | ·48 | 1·39 | ·49 | 1·10 |
| $Na_2O$ . | 1·48 | 2·76 | 2·17 | 3·53 |
| $H_2O$ (−) . | 1·04 | 1·28 | 1·05 | ·55 |
| $H_2O$ (+) . | 2·62 | | 4·27 | 3·14 |
| $CO_2$ . | — | ·25 | — | — |
| $P_2O_5$ . | tr. | — | ·395 | — |
| F . . | — | — | ·058 | — |
| | 100·31 | 100·48 | 100·16 | 99·99 |
| Sp. Gr. . | 2·932 | 2·944 | — | 2·92 |

I. Diabase, with micropegmatite (granophyric diabase), Auchinstarry, Kilsyth.
II. Diabase, Whin Sill, Crags near Roman Station of Bourgovicus, Northumberland.[1]
III. Diabase, dark-coloured modification (somewhat weathered), Kettlestoun Quarry, Bathgate Hills.[2]
IV. Quartz Gabbro (intermediate type), east flank, Carn Llidi, 10 yards from margin of sill, St. Davids.[3]

[1] Teall, Q.J.G.S., 1884, vol. xl, p. 654.
[2] Falconer, T.R.S.E., 1905–6, vol. xlv, pt. i, p. 147.
[3] Elsden, Q.J.G.S., 1908, vol. lxiv, p. 281.

The annexed analyses of similar British rocks illustrate the remarkable uniformity of composition prevailing in this type. All are diabasic rocks with quartz or micropegmatite. The only point of difference in the Kilsyth rock is its higher content of alumina and its lower content of alkalis as compared with the rocks of the Whin Sill and St. Davids.

In Table II, cols. I–IV below, is given the mineral composition (norm) of the above rocks, calculated according to the method of Cross, Iddings, Pirsson, and Washington.[1] The augite is assumed to have the theoretical composition $CaO, (Mg.Fe)O, 2SiO_2$, and the hypersthene $MgO, FeO, 2SiO_2$.

TABLE II.

| | I. | II. | III. | IV. | | V. | VI. | VII. | VIII. |
|---|---|---|---|---|---|---|---|---|---|
| Quartz . . | 7·38 | 1·74 | 6·60 | — | } Micropegmatite | 10·16 | 10·08 | 9·38 | 6·67 |
| Orthoclase . | 2·78 | 8·34 | 2·78 | 6·67 | | | | | |
| Albite . . | 12·58 | 23·06 | 18·34 | 29·34 | } Plagioclase . | 53·17 | 46·97 | 42·53 | 51·30 |
| Anorthite . | 40·59 | 23·91 | 24·19 | 21·96 | | | | | |
| Augite . . | 2·75 | 13·63 | 20·04 | 13·79 | } Pyroxenes . | 27·14 | 32·55 | 31·63 | 32·34 |
| Hypersthene . | 24·39 | 18·92 | 11·64 | 18·55 | | | | | |
| Magnetite . | 3·25 | 5·10 | 3·02 | 3·04 | } Iron-ores . | 6·29 | 8·75 | 9·40 | 6·75 |
| Ilmenite . | 3·04 | 3·65 | 6·38 | 3·71 | | | | | |
| Water, $CO_2$, &c. | 3·66 | 1·53 | 5·77 | 3·69 | Water, $CO_2$, &c. | 3·66 | 1·53 | 5·77 | 3·69 |
| | 100·42 | 99·88 | 98·76 | 100·75 | | 100·42 | 99·88 | 98·76 | 100·75 |

A remarkable point about these calculated mineral compositions is the very large proportion of orthorhombic pyroxene they show. This is especially marked in the Kilsyth rock. The actual proportion of this mineral, however, is usually small and much lower than that of monoclinic pyroxene. In the Kilsyth rock it is very small indeed. The inference is, then, that the monoclinic pyroxene contains a considerable admixture of the hypersthene molecule. This has been directly proved by analysis in the case of the Whin Sill rock, the similar 'augite-diorite' of Southern India, and the St. Davids rock.

The mineral composition of these rocks shows much greater uniformity if quartz and orthoclase (= micropegmatite) be taken together, also albite and anorthite (= plagioclase), augite and hypersthene (= pyroxenes), and magnetite and ilmenite (= iron-ores), as shown in Table II, cols. V–VIII.

## VII. Affinities and Relationships of the Kilsyth-Croy Rocks.

The rocks described in this paper are identical in chemical composition and down to the minutest microscopical details with the Whin Sill, as described by Dr. Teall.[2] The latter, indeed, is the most southerly member of the great group of late or post-Carboniferous dykes and sills of South Scotland and North England. They are

[1] *Quant. Class. of Igneous Rocks*, 1903, p. 186 et seq. [2] Op. cit., p. 28.

essentially the same as the rocks described under various names by Elsden from the St. Davids area,[1] by Harker from Carrock Fell,[2] by Sollas from Barnavave, Carlingford,[3] and by Falconer from the Bathgate Hills.[4] If the search for similar or identical rocks be carried beyond these islands, it is found that diabase with micropegmatite has a worldwide distribution. In Europe it has been described by Tornebohm from Sweden and by Barrois from Brittany; in Asia it has been described by Holland from South India; in North America it occurs in the Lake Superior region and in New England, as described by Lawson, Lane, Hawes, and others; in South America Harrison has described it as occurring in great abundance in the interior of British Guiana; in Africa Howe has described it from the north-eastern territories of the Congo Free State; and lastly it has been described by Prior as occurring at South Victoria Land in the Antarctic Continent.

A feature of these rocks is the remarkably constant chemical composition of the normal type, containing plagioclase, pyroxenes, micropegmatite, and iron-ores in proportions similar to those of Table II. This type makes up the main mass of the intrusions, and must be regarded as representing the actual mass composition of the magma from which the rock was immediately derived. The sometimes highly basic marginal facies and the granophyric veins must be regarded as opposite differentiation products of this magma. Table III gives the chemical composition of a few selected foreign diabases with micropegmatite. These should be compared with the British examples given in Table I.

The mode of occurrence of this rock is also distinctive. It always occurs in thick, massive, vertical-sided dykes, which sometimes continue for many score miles across country, and also as thick, laccolitic protrusions from such dykes. The great E.–W. dykes of the Midland Valley of Scotland are a classic example. The great dykes described by Lawson in the Rainy Lake district of Canada are of exactly the same type.[5] They are all more or less vertical, traverse all formations indifferently, continue for great distances (in one case 100 miles), and are of fairly uniform width (60–150 feet). They are diabases with micropegmatite, precisely similar to the Scottish examples. Moreover, the fissures along which they occur, as in Scotland, are not necessarily faults. The St. Davids Head rocks, according to Elsden,[6] occur in thick vertical sills between almost perpendicular Arenig shales. The augite-diorites with micropegmatite, described by Holland from South India, occur as a great series of basic dykes piercing the older crystallines of that area. One of them is 100 yards wide. An enormous number of these dykes, with their associated laccolites, occur in the interior of British Guiana. They pierce a basement of Archæan gneisses, granites, and schists, and are

[1] Op. cit., p. 28.
[2] Q.J.G.S., 1894, vol. i, p. 311.
[3] Trans. Royal Irish Acad., 1894, vol. xxx, pp. 477–512.
[4] Op. cit., p. 28.
[5] "Report on Geol. of Rainy Lake Region": Ann. Rep. Geol. Survey Canada, 1887–8, pt. i, pp. 147–50.
[6] Q.J.G.S., 1908, vol. lxiv, p. 273.

anything from 50 feet to 500 yards wide. The latter dyke causes the great Tumatumari Falls on the Potaro River.[1] In South Victoria Land the rock occurs as great sills in the Beacon Sandstone, and at one point, at least, a large dyke or pipe of dolerite, 50 yards wide, was found cutting vertically through the sandstone beneath a sill.[2]

TABLE III.

| | I. | II. | III. | IV. |
|---|---|---|---|---|
| $SiO_2$ | 52·68 | 51·19 | 53·26 | 51·15 |
| $TiO_2$ | — | ·40 | ·70 | ·44 |
| $Al_2O_3$ | 14·14 | 15·80 | 15·64 | 15·92 |
| $Fe_2O_3$ | 1·95 | 3·08 | ·24 | 9·34 |
| $FeO$ | 9·79 | 11·20 | 7·44 | 2·87 |
| $MnO$ | ·44 | tr. | ·11 | ·09 |
| $MgO$ | 6·58 | 5·63 | 8·64 | 6·48 |
| $CaO$ | 9·38 | 9·58 | 12·08 | 10·40 |
| $Na_2O$ | 2·56 | 2·09 | 1·25 | 1·19 |
| $K_2O$ | ·87 | ·60 | ·58 | 1·61 |
| $H_2O$ | 1·60 | ·30 | ·76 | ·11 |
| $CO_2$ | — | none | ·04 | — |
| $P_2O_5$ | — | ·008 | — | ·06 |
| $F$ | — | — | — | — |
| $FeS_2$ | — | ·005 | — | — |
| | 99·79 | 100·883 | 100·74 | 99·66 |
| Sp. Gr. | 2·97 | — | — | 3·19 |

I. Diabase, Mt. Holyoke, Massachusetts.[3]
II. Diabase, dyke, Potaro River, British Guiana.[4]
III. Dolerite (with Micropegmatite), Knob Head, South Victoria Land.[5]
IV. "Augite-Diorite with Micropegmatite," Seven Pagodas, Chingelput, India.[6]

In Scotland the great dykes occur as an after-phase of great extrusions of basic lavas. In India the augite-diorite dykes are believed to be associated with the basic Cuddapah lavas. Lawson suggests a relation between the great dykes of the Rainy Lake region and the Animikee and Keweenawan traps of that district. In Skye and other British centres of Tertiary volcanic activity, great extrusions of plateau basalts are followed by the intrusion of gabbro and granophyre in intimate relations, rocks which, if mixed a little more thoroughly, would be identical with granophyric diabase.

[1] Harrison & Perkins, *Rep. on Geol. of Essequibo and Potaro Rivers*, Georgetown, 1900, p. 35. Also Harrison, *Geol. of the Goldfields of British Guiana*, 1908.
[2] Ferrar, *Nat. Antarctic Exp.*, 1907, vol. i, "Geology," p. 50.
[3] Hawes, Amer. Journ. Science (3), 1875, vol. ix, p. 186.
[4] Harrison & Perkins, *Rep. on Geol. of Essequibo and Potaro Rivers*, 1900, p. 64.
[5] Prior, *Nat. Antarctic Exp.*, 1907, vol. i, p. 137.
[6] Holland, Q.J.G.S., 1897, vol. liii, p. 409.

*Origin.*—As I have not yet completely investigated the literature, I do not know whether these generalizations are true of every occurrence of diabase with micropegmatite. There are obvious difficulties in the way of proving their truth. If they are true, then it is certain that these facts have not only a very important bearing on the petrogenesis of diabase with micropegmatite, but also on petrogenesis in general. In Scotland both plateau basalts and the great dykes of diabase with micropegmatite appear to be connected with the great block fractures due to radial contraction of the earth. If this relation can be shown to hold elsewhere, it may open up attractive speculation as to the association of certain types of igneous rock, and perhaps certain modes of differentiation, with particular kinds of earth-movements.[1] In this field the recent work of Becke and Prior is sufficiently well known.

In the lack of synthetic data bearing on the origin of granophyric diabase, any theory must be regarded as purely speculative. In his very suggestive papers on the Mechanics of Igneous Intrusion,[2] Dr. R. Daly has advocated the theory of abyssal assimilation with subsequent gravity differentiation as a mode of origin of many igneous rocks. He believes that these owe their origin to the interaction of a postulated universal layer of potentially-liquid rock of gabbroid composition in the crust beneath the level of no strain, with the overlying acidic crust, the interaction taking place in chambers formed by 'magmatic stoping'. In one of his papers Dr. Daly hints that the peculiar field relations of gabbro and granophyre, so perfectly displayed in many parts of the United Kingdom, may be susceptible of explanation on the abyssal assimilation theory. It is impossible here, however, even to indicate in the barest outline the detailed facts and calculations upon which Dr. Daly bases his theory.

The suggestion is here put forward that the gabbro-granophyre mélange rocks owe their origin to the interaction of a normal basalt-magma with a highly siliceous country rock, in the manner advocated by Dr. Daly, and that the normal granophyric diabases, with their remarkably constant chemical composition, represent the saturation-point of such a magma with silica. The excess of siliceous matter is believed to be thrown out as a separate body of material usually consolidating as granophyre, in a manner analogous to the separation of the excess of a salt in a saturated solution. The theory thus crudely set forth can only be barely indicated, much less discussed, in this place. It depends largely on further synthetic research as to whether there is such a saturation-point for a basic magma in which silica has been dissolved. That granophyric diabase represents a critical point in the history of its magma may perhaps be inferred from the fact that it is almost entirely made up of intergrowths of related minerals. The iron-ore is made up of intergrown magnetite and ilmenite, the pyroxene probably of submicroscopic intergrowths of augite and

[1] See H. I. Jensen, "Distribution, Origin, and Relationships of Alkaline Rocks": Proc. Linn. Soc., N.S.W., 1908, vol. xxxiii, p. 491.

[2] Amer. Journ. Sci. (4), 1903, vol. xv, p. 269; (4), 1906, vol. xxii, p. 195; (4), 1908, vol. xxvi, p. 17. Also "Secondary Origin of certain Granites": A.J.S. (4), vol. xx, p. 185.

hypersthene, the highly zonal felspars may be considered as intergrowths of various plagioclases, and the final product of crystallization is an intergrowth of quartz and orthoclase.

New synthetic data as to the products of the fusion of plateau basalts or ultra-basic rocks with acid gneisses, schists, and sandstones, under varying conditions of temperature and pressure, might possibly throw some light on the problem. It is worthy of note in this connection that the magma-reservoirs of many occurrences of granophyric diabase may reasonably be supposed to be located in a highly siliceous country rock. The rock is very common in areas of fundamental gneiss, as in Scandinavia, Rainy Lake region of Canada, the interior of British Guiana, and Southern India. In Scotland the area is probably underlain by many thousand feet of Caleiferous Sandstone, Old Red Sandstone, and perhaps the Dalradian gneisses and schists.

## VII.—The Rhætic Section at Wigston, Leicestershire.

By L. Richardson, F.R.S.E., F.L.S., F.G.S.

At the Glen-Parva Brickworks, Wigston, near Leicester, is the finest section of the Rhætic beds that is to be seen in the Midlands. The large subcircular pit where the beds are displayed at once arrests the attention of the traveller on the adjacent railway as an excavation of more than usual size.

At the base of the pit are the red and greenish-grey-zoned marls of the Keuper, replete with layers of pink gypsum; then come the tea-green marls of the same series, well marked-off from the red rocks below and the markedly black shales of the Rhætic Series above; while at the top, at the western end of the pit, come reddish-stained gravels, and at the eastern the pale-yellowish marls and limestones of the Upper Rhætic succeeded by the basal beds of the Lower Lias with but a sprinkling of gravel here and there.

Naturally so fine a section as this has not escaped attention. It has been measured in detail by Edward Wilson and H. E. Quilter,[1] and investigated later by Mr. Montagu Browne,[2] who, in a report of an excursion of the Leicester Literary and Philosophical Society, has given pictures of the pit, diagrammatic sections, and criticisms on his predecessors' work. Others have briefly referred to it,[3] and Mr. C. Fox-Strangways in the Geological Survey Memoir on "The Geology of the Country near Leicester" (p. 16), has summarized the information that had been published previous to his time of writing.

The object, then, of this communication is obviously not to give a record of an entirely fresh section, but merely to suggest a somewhat different reading of a well-known one.

Commencing at the base of the section, the 12 to 15 feet of "Tea-green Marls" are very distinct, and the line of demarcation between them and the *Pteria-contorta*-Shales is exceptionally sharply defined.

[1] Geol. Mag., 1884, Dec. III, Vol. I, pp. 415–18.
[2] Trans. Leicester Lit. and Phil. Soc., 1901, vol. vi, pt. i, pp. 32–8.
[3] Idem, N.Q.S., 1889, vol. i, pt. ii, p. 14; A. S. Woodward, idem, p. 22.

Mr. A. R. Horwood, of the Leicester Museum, who read through this paper in its manuscript form and kindly made a special investigation of this section at my request, says (*in litt.*) that the lithic structure of the Tea-green Marls is quite different from that of the grey bands that are associated with the red marls.

The bone-bed is ill-defined as a hard bed, but there is usually present gritty matter, replete with fish coprolites, scales, teeth, pebbles, and an occasional fragment of bone, resting directly upon the Tea-green Marls. It is easily found by searching along the actual junction-line and looking closely for the black vertebrate remains. Mr. Montagu Browne remarks that it rests upon "an eroded surface of the marls".

Section at the Glen-Parva Brick-Works, Wigston.

| | | | *Thickness in* ft. | in. | |
|---|---|---|---|---|---|
| Drift. | | Reddish clay, sand, and boulders: 8 to 27 feet. | | | |
| Lower Lias. | *c* | Shales, thinly laminated, dark grey (weathering yellowish), and crowded with fragments of echinoid-radioles and shell-débris: seen | 1 | 0 | Fragments of the radioles of echinoids and débris of *Ostrea liassica*, Strickl., *Plagiostoma* sp., *Volsella minima* (Sow.), and *Syncyclonema* sp. |
| | *b* | Limestone, fissile, hard, grey, blue-hearted, crystalline, almost made up of the fragments of echinoid-radioles and oysters: 1 to 3 inches | 0 | 2 | |
| | *a* | Marl, pale-yellow, sometimes shaly: 0 to 10 inches | 0 | 5 | ? = Paper Shales. |
| | | | 1 | 7 | seen |
| *Non-sequence.* | | | | | |
| Upper Rhætic. | 1 | Limestone, pale-yellow, greyish, blue-hearted, occurring in somewhat nodule-shaped masses, but continuous, and usually separating into two beds of like thickness: 10 inches to 1 foot. | 0 | 10 | |
| | 2 | Marls, yellowish, indurated, or an impure limestone: 4 to 8 inches. | 9 | 9 | Annelid-tracks and burrows. |
| | 3 | Limestone, impure, irregular, laminated, earthy, grey (weathering brown): 0 to 2 inches. | | | |
| | 4 | Marls, pale-yellow, occasionally laminated, but more often breaking with cuboidal fracture, with sandy and micaceous seams, scattered pyritic nodules, and more or less continuous indurated bands (one of which is particularly noticeable at or near the base): passes down into | | | |
| | | | 10 | 7 | |

| | | | Thickness in ft. | in. | |
|---|---|---|---|---|---|
| Lower Rhætic. | 5*a* to 8 | Shales, black, at first clayey, with thin seams of sandstone, the most noticeable, 1½ inches thick, at about 3 feet above 9 | 9 | 3 | |
| | 9 | Limestone, pale bluish-grey, with fissures filled in with calcite and occasionally with barytocelestine | 0 | 5 | ["*Estheria minuta*," *teste* M. Browne.] |
| | 10 | Shales, black, less fissile in the upper portion | 13 | 0 | *Isocyprina Ewaldi* (Born.), *Chlamys valoniensis* (Defrance). |
| | 11 | Limestone-nodules, pale bluish-grey, septariform, with radiating gypsum | 0 | 3 | ["? *Estheria minuta*," *teste* M. Browne.] |
| | 12 | Shales, fissile, gypseous, somewhat sandy | 4 | 0 | *Isocyprina Ewaldi* (Born.), *Protocardia rhætica* (Merian), *Pteria contorta* (Portlock), *Chlamys valoniensis* (Defrance), *Pholidophorus Higginsi*, Egerton, scales of *Gyrolepis Alberti*, Ag. |
| | 13 | Rust-coloured layer | 0 | 1 | |
| | 14 | Shales, thinly laminated in the upper portion, but more thickly laminated below | 2 | 8 | *Pteria contorta* (Portlock), *Isocyprina Ewaldi* (Born.), *Gyrolepis Alberti*, Ag. (scales and teeth). |
| | 15 | Bone-bed: 0 to 1 inch | 0 | 1 | *Acrodus minimus*, Ag., *Hybodus minor*, Ag., *Saurichthys acuminatus*, Ag., *Gyrolepis Alberti*, Ag., *Colobodus* sp., ichthyodorulite of *Nemacanthus* (fragments), etc. |
| | | | 29 | 9 | |
| Keuper. | *Non-sequence.* i | Tea-green Marls: 12 to | 15 | 0 | |
| | ii | Red marls with greenish-grey zones and pink gypsum: seen | 12 | 0 | |
| | | | 27 | 0 | seen |

The very sharply defined line between the Tea-green Marls and the *Pteria-contorta*-Shales would suggest that this was the case, apart from the fact that it is now known that the Sully Beds intervene where the sequence from Keuper to Rhætic is as complete as it is everywhere in this country. Thus at Wigston the Keuper and Rhætic deposits are conformable to one another, but are nevertheless non-sequential.

On the south side of the pit, namely, that opposite to Glen-Parva Station, and immediately to the west of the ash-tip, it will be noticed that above the really black shales are pale yellowish and greenish-brown marls, somewhat laminated in places, with a pale-coloured limestone-bed at or near their base. Now it is at or may be a few

inches below this limestone-bed that I would draw the line between the Lower and Upper Rhætic, thus making the Upper Rhætic the yellowish and practically unfossiliferous portion and the Lower Rhætic the darker and distinctly fossiliferous portion.

Wilson and Quilter drew it at 2 feet below the most prominent limestone-bed in the section, that is, below bed 9; but Montagu Browne would take that bed, his bed G, as the "break between the Upper and Lower Rhætic, which appears", he says, "rather to be determined by the thick band of limestone (G) than by shales that 'pass down' into similar ones" (p. 36).

At an earlier page (p. 32), however, Mr. Montagu Browne writes: "The dark shales following above this basal bone-bed are those known as the Lower Rhætic 'Black Shales', 'Paper Shales', in whole or in part, or *Avicula-contorta*-Shales (D), and are generally carried as far as the second band of limestone (G). In this instance I would prefer to limit them, if not just under the first band of limestone (E), to not far above that horizon, on both lithological and palæontological grounds." So apparently he did not form any very definite idea as to where the line should come.

As Wilson and Quilter remark, the feature of the *Pteria-contorta*-Shales that at once strikes anyone familiar with the Rhætic of the South-West of England is the rarity of hard bands. In the 29 feet 9 inches of deposit assigned to the Lower Rhætic there are only two noticeable hard bands, both limestones. The lower one is a line of well-spaced septariform nodules, more widely separated than Mr. Montagu Browne's diagrammatic section would lead one to infer. The upper and principal band, however, is more continuous, being made up of blocks of septariform limestone less commonly nodular. This bed much reminds one of a similar limestone numbered 9 at Langport and at several other Somerset sections.

There is not so great a variety of Rhætic fossils as might be expected in these beds, but along certain lines such species as do occur are individually very numerous, and fish—more perfect than is often the case—are not uncommon at from 3 ft. 6 in. to 3 ft. 9 in. above the base of the shales. A single ray of *Ophiolepis Damesi* has been found, but not *in situ*. This is unfortunate, for its detection *in situ* would have materially contributed towards the more accurate correlation of the component beds of this section with their equivalents elsewhere, seeing that it probably marks out a niveau at some 2 or 3 feet below the Lower *Pecten*-Bed.

The queried record of *Estheria minuta* in bed E of Mr. Montagu Browne's section, and the apparently certain record from his bed G, require confirmation. Neither limestone looks to me at all like those in which one would expect to find this phyllopod, and Mr. A. R. Horwood—who kindly made a special search at my request—also failed to detect any specimens. I should rather anticipate their discovery in the marls and associated beds of the portion that I have identified as Upper Rhætic.

It is obvious from the details that have been recorded by Mr. Montagu Browne that these beds are subject to considerable variation, and that, as I have also observed, the marls distinguished as *a* (Lower Lias) are

often absent and then the fissile limestone *b* comes to rest directly upon the limestone numbered 1. A compound bed is the result, the upper portion of which belongs to the Lower Lias, and the lower to the underlying Rhætic Series. Since the upper portion has yielded *Psiloceras planorbis* on the testimony of both Wilson and Quilter and Mr. Montagu Browne, it is obvious that it belongs to the *Planorbis*-Zone. Wilson and Quilter regard the lower portion as the top-bed of the Upper Rhætic; but Mr. Montagu Browne would claim it as belonging to the "Liassic Basement Beds = Sub-Lias = *Ostrea*-Zone" (p. 37). On an earlier page he says that this "Sub-Lias" is the "White Lias" of some authors, which would lead one to suppose that some authors have used the terms "*Ostrea*-Beds" and "White Lias" synonymously; but I am not aware of any such confusion. Mr. Montagu Browne further states that here and there embedded in the lower portion of the inferior part of the compound bed referred to above are nodules that may represent the Cotham Marble. If such is the case, then the limestone-band that is overlaid by a limestone-bed of *planorbis* hemera and underlaid by nodules on the horizon of the Cotham Marble occupies the stratigraphical position of the *Ostrea*-Beds, Insect and Crustacean Beds, and White Lias of Mid Somerset. The lithic and faunal characters of the bed, however, do not point to contemporaneity with either the *Ostrea*-Beds or Insect and Crustacean Beds, and until the presence of a representative of the Cotham Marble has been more satisfactorily demonstrated, I should prefer to regard the limestone in question, which usually separates into two layers, as comparable with the *Pseudomonotis*-Bed of Garden Cliff, which also admits of similar dual division.

The closeness of deposits containing *Psiloceras planorbis* to undoubted Rhætic Beds is very interesting, and the difference in fauna is readily explained by the magnitude of the non-sequence.

One of the main objects of this communication is to state or emphasize the point that the marls of the Upper Rhætic are not—as supposed in 1884 by Wilson and Quilter, and in 1908 by Mr. C. Fox-Strangways—an argillaceous development of the White Lias of Somerset, and therefore of the same age. Mr. Montagu Browne noticed that these Upper-Rhætic marls of Wigston were represented at Aust Cliff, and records that he convinced his friend Edward Wilson of the fact. The Upper-Rhætic is indeed a most persistent deposit, quite distinct from the White Lias where the White Lias is developed, and everywhere underlying it.

## VIII.—The Flow of Antarctic Ice.

By R. M. Deeley, F.G.S.

In his interesting and excellent *Voyage of the Discovery* Captain R. F. Scott *speculates* on the former ice conditions of the Ross Sea and the adjacent ice-formations. He regards the views he expresses on this subject as only speculations, so I trust that I shall not be considered ungenerous if I attempt to express what I understand

to be his views, and then subject them to criticism. It may be that I have misunderstood Captain Scott. If this should be the case the method of treatment proposed will prevent confusion.

Referring to the Great Barrier ice Captain Scott writes: "On the slopes of Terror Dr. Wilson found morainic terraces 800 feet above the present surface of the ice. Mr. Ferrar showed that nearly the whole of the Cape Armitage Peninsula was once submerged; and, in fact, on all sides of us and everywhere were signs of the vastly greater extent of the ancient ice sheet." "It is not until one has grasped the extent of the former glaciation and the comparatively rapid recession of the present that one can hope to explain the many *extraordinary ice formations that now remain in the Ross Sea.*" (The italics are mine.) "The Ross Sea is comparatively uniform in depth north and south: the ice sheet pressing over this level floor would consequently have been more or less uniform in thickness, and, finally, the wastage would have been *more or less uniform over the whole area.*" "I imagine that it floated away gradually, and that the present rapidly diminishing Barrier is *the remains of the great ice sheet.*" "It is not the only *remains*, for the whole coast bears signs of the old ice sheet in curious ice formations that can be *accounted for in no other way.* Lady Newnes Bay contains a *large fragment of it*; the present ice discharges are wholly insufficient for such a sheet as *fills the bay.*" "In the course of the narrative I referred to the long ice tongue in latitude 75° S.; this must also be a *remnant* of the heavier glaciation. Other typical remnants are to be found in the steep snow slopes and ice-cliffs which fringe many parts of the coast. These slopes, which are very common about our winter quarters, start on a bare hill-side, and, *wedge-shaped* in section, gradually increase in thickness till they *end in a perpendicular cliff dipping into the sea, consequently they have no present source of supply.*"

Taking these paragraphs together, Scott appears to hold that in Victoria Land there are masses of ice which are not in motion, receive no continuous supply of fresh snow to form fresh ice, and are, consequently, masses of ice which are actual remnants or portions of the great ice-sheet which have not melted.

Mr. Ferrar also seems to hold the same views, for he refers to Piedmonts as "Large areas of ice which lie at the foot of high land, and which have no obvious single source". And again: "The great *snow-fan* between the hills and the stranded moraines on the west side of McMurdo Sound may be taken as an example. This mass of *snow* is about 10 miles long and 5 broad, and the whole of it is aground. It has no obvious source, and the surface rises from a few feet at the *seaward edge* to about 1000 feet on the sides of the foot hills. As it is *practically motionless* it must afford very material protection to the land."

It seems to me to be much more probable that the ice masses or sheets referred to are recruited by the snow which falls on them directly from the clouds or is blown on to them from the adjacent rocky slopes. Also that they are really in more or less rapid motion, and are being wasted away where they reach the sea or a point where the sun is strong and very little snow collects.

In the case of the Great Barrier the ice presents a high vertical face to the sea, and the whole mass is moving from the south at a rate of about 600 yards per annum. Now if we place the origin of the Barrier ice, as such, about 400 miles from the seaward face, near where it is fed by the magnificent glacier discovered by Shackleton, the whole of it will have broken off at the sea face and have been replaced in about 1200 years. No portion of it, therefore, can be a remnant, i.e. the remains of the former ice-sheet. It has merely become thinner, as the supply of snow falling upon the area became less, and the tributary glaciers became smaller, just as the water-level of a river rises and falls as the rainfall varies.

The same argument applies to the other more local ice formations. They commence on a hill-side and thicken as they approach the sea, at which they terminate in a vertical face. Now Scott and Ferrar have shown that the sea has a very rapid wasting effect upon the ice which reaches it. The cliffs are undercut and large masses break off. Even the sea ice is being rapidly melted from beneath when the upper surface is below the freezing-point. The vertical face which faces the sea is maintained by the continual motion of the ice-foot towards the sea.

With regard to the peculiar ice-islands, a photograph of one off King Edward's Land is shown. This I take it is regarded as a remnant of the old ice-sheet. The photograph shows a mass of ice, with an irregular upper surface sloping roughly towards the sea in all directions. It terminates on the sea face in an overhanging cliff of considerable height. May not these ice-islands be rocky islands upon which more snow falls than is melted by the sun? In such a case the ice-cap would reach a thickness sufficiently great to allow it to discharge the ice seawards. A section would show two wedge-shaped areas terminating in seaward cliffs. In other words the ice-islands are the island equivalents of the shore ice.

From the photographs shown, and the descriptions of the various ice formations, I see no signs of extraordinary stagnation. On the contrary, the ice is everywhere in motion, to judge from the usual signs.

Ice is a viscous substance—a peculiar one in some respects, it is true. Water, oil, honey, and pitch are also viscous. To ascertain how these substances will act in any case it is necessary to know how viscous they are. The unit of viscosity is measured by the tangential force per unit area of either of two horizontal planes, at the unit distance apart, one of which is fixed while the other moves with unit velocity, the space between the planes being filled with the viscous substance. The viscosity of liquids can be measured in many ways. Thin oils, water, spirits, etc., are best dealt with by measuring their rate of flow through capillary tubes. For thick oils, honey, etc., tubes having larger diameters must be used. For pitch the conditions of flow through large holes in thin plates or the flow down troughs give satisfactory results. For glaciers, if we know the rate of flow, the inclination, and the width and thickness, the result can be calculated directly.

The following table gives the viscosity of some liquids :—

| *Liquid substance.* | *Viscosity in c.g.s. units.* |
|---|---|
| Glacier ice at 0° C. | about 125,000,000,000,000 |
| Crystalline ice at 0° C. in a direction at right angles to the optic axis | 20,000,000,000 |
| Pitch | 40,000,000,000 |
| Shoemakers' wax | 6,000,000 |
| Mineral cylinder oil | about 10 |
| Sperm oil at 100° F. | ·185 |
| Mercury at 10° C. | ·016 |
| Water at 20° C. | ·010 |
| Alcohol at 20° C. | ·001 |

This table shows the wide range of viscosities to be found in different substances. It will be seen that if the ice-sheets are in a state of stagnation, considering the slopes available for producing motion, the viscosity of the ice of which they are formed must reach an enormous figure. The calculations I made to ascertain the viscosity of the Swiss glaciers gave figures varying from $3{\cdot}274 \times 10^{12}$ to $292{\cdot}2 \times 10^{12}$. Some of the data were certainly somewhat uncertain; but it would appear that all glaciers have not the same viscosity, owing, I think, to differences in the sizes and arrangement of the glacier grains. We have no information, as far as I am aware, of the sizes and arrangement of the glacier grains of the extensive Arctic and Antarctic glaciers; but I do not think that their granular structure can be so coarse that they are in any cases stagnant.

The volume of ice discharged by a glacier of great width in proportion to its thickness is, *ceteris paribus*, proportional to the cube of its thickness. It is no doubt due to this fact that the thicknesses of glaciers and ice-sheets in proportion to their areas do not vary as much as one would at first sight expect them to.

Whenever actual measurements have been made ice-masses have been found to be moving under the influence of gravity. From the nature of the movement which is set up the flow is clearly viscous, and although calculations prove that ice in mass possesses a viscosity which varies somewhat according to its structure, it is always sufficiently small to allow of its more or less rapid flow.

## REVIEWS.

### The Geological Survey.

I.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1908. pp. iv, 98, with 3 text-illustrations. London: printed for H.M. Stationery Office, 1909. Price 1*s*.

COMPARED with the *Summary of Progress* for 1907, noticed in the Geological Magazine for August last year, the present memoir contains less material, to the extent indeed of 77 pages. The record of the work done has been abbreviated, and this is no disadvantage, as the matter in due course is for the most part reproduced in the memoirs explanatory of the Geological Survey maps.

We learn that the mapping of the Pembrokeshire portion of the

great South Wales coal-field has been nearly completed; and that the survey of West Cornwall, including the Lizard area, has been finished. In the Midland district the survey of the Derbyshire and Nottinghamshire coal-field has been carried northwards towards the borders of Yorkshire. In Scotland work has been continued in the Northern, Central, and Western Highlands, including portions of Caithness and the island of Mull, while progress has been made with the re-survey of the coal-fields.

Among the points of special interest to which the Director, Dr. Teall, calls attention, is the evidence of certain 'fold-faults', which have been found to occur in the neighbourhood of Glen Etive, Loch Leven, and Glen Nevis. These are recumbent folds more or less dislocated, and in certain cases subsequently rucked up and involved in other isoclinal folds, whereby the task of the geological surveyor becomes about as difficult as it well can be. In South Wales the oldest Cambrian strata, referred to the Caerfai group of Dr. Hicks, have been proved to rest unconformably on pre-Cambrian rocks. Attention has been given to the marine bands, first described by J. W. Salter, in the Old Red Sandstone of West Angle Bay in Pembrokeshire. They are regarded as representing temporary incursions of the sea into the area prior to and foreshadowing the marine conditions of the Lower Carboniferous.

Observations on the coals of Lanarkshire point to the conclusion that the lateral change from bituminous coal to anthracite is in some way connected with original differences in composition, as was suggested in reference to the coals of South Wales, recently described in a Survey Memoir.

In the Petrographical department investigations have been made on the felspathic hornstones from the aureole of the St. Austell granite, and on nepheline rocks from the midland valley of Scotland.

In the Palæontological department attention has been given to the species of *Productus* found in the Carboniferous rocks, with the view of defining forms that characterize the zonal subdivisions in the Limestone Series. We are glad to learn that a memoir is in preparation on the Secondary formations proved in some of the deep borings in Kent. From the preliminary notices we learn that the Hastings Beds at Dover rest on an irregular surface of Kimeridge Clay, and that the lowest bed of the Lower Lias, which rests directly on Coal-measures at Dover, belongs to the *Capricornus* zone. Elsewhere at Brabourne it appears that the Lower Lias rests directly on Triassic marls, without any evidence of intervening Rhætic beds.

The Appendix contains an article "On a Boring in the Fullonian and Inferior Oolite at Stowell, Somerset", by Mr. John Pringle, who obtained a very interesting series of fossils. They indicate that the Lower Fullers Earth clay should be grouped with the Inferior Oolite Series, and the Fullers Earth rock and overlying clay with the Great Oolite Series.

There is a second article "On the Stratigraphical Position of the Achanarras Fauna in the Old Red Sandstone of Caithness", by Mr. R. G. Carruthers. The Achanarras fauna occurs near Spital, to the south of Thurso, and was originally described by Dr. Traquair as

yielding a different set of fishes from that of the Thurso flagstones. The same fauna has now been found near Latheron on the southern coast of Caithness, and its stratigraphical position has been determined to be beneath that of the Thurso flagstones (of Sir A. Geikie) which form the higher portion of the upper or *Coccosteus* group of the Caithness flagstones.

It is to be hoped that Mr. H. A. Allen's valuable Catalogue of Types and Figured Specimens preserved in the Museum of Practical Geology will be continued in future numbers of the *Summary of Progress*.

II.—Stratigraphie des Kohlenkalks in der Umgebung von Krakau. [The Stratigraphy of the Carboniferous Limestone in the Neighbourhood of Cracow.] By J. Jarosz. Extr. du Bull. de l'Académie des Sciences de Cracovie (pp. 689–706), Avril, 1909, Cracovie.

THIS paper commences with the geographical delimitation of the district under consideration and a short historical sketch of the work of previous investigators. Then follows the petrographical and palæontological characteristics of a series of exposures. The examination of the Brachiopods from these exposures points to the presence of two distinct faunas of different horizons and occurring in beds petrographically distinct from one another. The one horizon is distinguished by more or less dark limestones, often bituminous and containing here and there an abundance of chert. This limestone contains at one place (Szklarka-Tal) a thin crinoidal band comparable to the *petit granite* of the lower horizon in Belgium. Forms which are peculiar to this horizon are *Athyris roissyi*, *A. squamigera*, *A. lamellosa*, *Spirifer tornacensis*, *Sp. cinctus*, *Syringothyris cuspidata*, *Productus margaritaceus*, *Pr. spinulosus*, *Pr. mesolobus*, *Chonetes hardrensis*, *Lingula credneri*, *Discina davreuxiana*. The other horizon is characterized for the most part by light-coloured, compact or granular limestones, often becoming whitish, yellowish, or bluish-grey, and sometimes also massive and reddish. Among forms peculiar to this horizon are *Dielasma sacculus*, *Athyris expansa*, *A. globularis*, *A. subtilita*, *Spirifer duplicicosta*, *Sp. trigonalis*, *Sp. ovalis*, *Spiriferina cristata*, *Rhynchonella acuminata*, *Rh. pugnus*, *Rh. pleurodon*, *Rh. angulata*, *Productus giganteus*, *Pr. latissimus*, *Pr. costatus*, *Pr. undatus*, *Pr. wrightii*, *Pr. nystianus*, *Pr. aculeatus*, *Pr. punctatus*, *Chonetes comoides*, *Ch. papilionacea*, etc. After a comparative examination of the faunas and those of Belgium the author correlates the two horizons mentioned, the first with that of Tournay, the second with that of Visé.

The paper is accompanied by a plate of fossil illustrations and a sketch-map of the district.

I. T.

III.—The Darwin Centennial Commemoration.

ON July 1 of last year the Linnean Society held a special meeting to celebrate the fiftieth anniversary of the reading of the papers on "Natural Selection" by Charles Darwin and Alfred Russel Wallace.

It is remarkable that the present year is rendered famous by the centenary of the birth of Darwin, and by the jubilee of the publication of his *Origin of Species*, events which have been fittingly celebrated at home and abroad.

February 12 being the birthday of Darwin, that date was chosen at Oxford, and the hundredth anniversary was celebrated by a reception given in the examination schools by Professors S. H. Vines, E. B. Poulton, and G. C. Bourne. It is noteworthy that the proceedings were opened by the Dean of Christ Church, while an address on "Fifty Years of Darwinism" was delivered by Professor Poulton.[1]

In America, on the same date, besides other gatherings, there was a special celebration at Columbia University, New York, when Dr. Henry Fairfield Osborn gave an address on the "Life and Works of Darwin". This has been printed (in the *Popular Science Monthly* for April), with eight portraits, including that of the bust of Darwin by William Couper, a copy of which in bronze was presented to Christ's College, Cambridge.

Naturally the chief celebration was held at the University of Cambridge, where Darwin, as an undergraduate at Christ's College, gained inspiration in natural science and laid the foundations of his great career.

Proceedings were opened at the Fitzwilliam Museum on June 22, with the reception of delegates and other invited guests by Lord Rayleigh, the Chancellor of the University. The invitations were confined almost entirely to naturalists.[2]

On June 23 Lord Rayleigh gave a brief address in the Senate House, and remarked that "What appeals to all is the character of the man, loved by everyone who knew him, and admired by everyone with a spark of the scientific spirit. It is a pleasure and a stimulus to think of him, working on in spite of ill-health in his study, in his garden, and in his hot-houses, and from his retirement moving the minds of thinking men in a manner almost without parallel".

The presentation by delegates of addresses from all parts of the world was accompanied by a few speeches. Then Sir Ray Lankester, on behalf of British naturalists, referred to the inspiration given to Darwin by Henslow, remarking that it was through "the influence of his splendid abilities and high personal character upon Darwin that Cambridge acquired the right to claim the author of the *Origin of Species* as a product of her beneficence and activity as a seat of learning". If Darwin did not explain the origin of variation, he explained the origin of species by the preservation of minute variations favourable to existence under prevailing natural conditions, and he "furnished the key to the explanation of what are called useless specific characters and of incipient organs".

On June 24 Sir Archibald Geikie delivered the Rede lecture, which was included in the proceedings of the celebration, and he chose as his

[1] See also his recently published *Essays on Evolution*, 1908.

[2] For many particulars here recorded we are indebted to *Nature* for June 10, June 24, and July 1.

subject "Charles Darwin as Geologist".[1] In the course of his lecture he remarked that "Darwin began his active scientific career as a geologist, that it was mainly to geological problems that the earlier years of his life were devoted". While he gained some acquaintance with geology at Edinburgh from Jameson, his interest was not aroused until he proceeded to Cambridge. There he was introduced by Henslow to Sedgwick, with whom he made a geological excursion into North Wales. It was, however, to Lyell's *Principles of Geology*, the first volume of which he took with him on the voyage of the "Beagle", that his enthusiasm in the pursuit of that science was chiefly due. The second and third volumes were afterwards sent out to him.

By his geological observations made during that voyage, in South America and other lands, especially his investigations on volcanic islands, on volcanic phenomena, and continental elevations, and on the structure and distribution of coral-reefs, science was remarkably enriched.

Although some of Darwin's conclusions have not withstood the test of later researches, notably in regard to explanations of particular glacial phenomena, and of certain of the atolls among coral islands, yet his contributions to their science have been so great that, as Sir A. Geikie remarks, "Geologists are proud to claim him as one of themselves and as one of the great masters by whom their favourite science has been advanced." By his extended observations on vegetable mould he illustrated some of the changes which the earth's surface is undergoing; finally, by his *Origin of Species* he illumined the whole aspect of the science, and especially the palæo-zoological and palæo-botanical branches.

On this subject "the far-reaching influence of Darwin's work on the progress of knowledge, and the present attitude of original investigators and thinkers towards the views contained in Darwin's works", are embodied in a series of essays combined in a memorial volume, entitled *Darwin and Modern Science*, edited by Professor A. C. Seward. The essay on "Darwin and Geology" is written by Professor Judd. Another notable volume, entitled *The Foundations of the Origin of Species*, edited by Francis Darwin (1909), contains a sketch of the *Origin of Species*, written by Darwin in 1842, and of great historic interest.

## REPORTS AND PROCEEDINGS.

### I.—Mineralogical Society.

*June* 15.—Principal H. A. Miers, F.R.S., President, in the Chair.

Carnotite and an associated mineral-complex from South Australia; by Messrs. T. Crook & G. S. Blake. The carnotite of Radium Hill, near Olary, South Australia, occurs in a definitely crystalline condition. The crystals are tabular and orthorhombic in symmetry. The carnotite

[1] Printed as a separate volume at the University Press, Cambridge, pp. 91, price 2*s.* net.

of Colorado, though not so definitely crystalline, also contains tabular crystals which are orthorhombic in symmetry, and probably identical in mineral characters with those of South Australia. From the general characters of these crystals, it appears that carnotite is a mineral belonging to the Uranite group, and that it may be regarded as the vanadium analogue of autunite. The black lodestuff in which the Radium Hill carnotite occurs is heterogeneous in constitution. It consists essentially of ilmenite, which is impregnated with magnetite, rutile, carnotite, and a mineral which is possibly tscheffkinite. The evidence provided by a study of the complex does not necessitate the view that new minerals are present, such as that to which the name 'davidite' has been given.—On the species Pilolite, and the analysis of a specimen from China; by Mr. G. S. Whitby. The specimen examined is from a new source, and possesses the formula $Al_2O_3 . 2SiO_2$, $2(MgO . 2SiO_2)$, $7H_2O$; a formula which is simpler than those given by Heddle and by Friedel to the pilolites which they investigated. The author considered that for the present the term pilolite should be applied to those varieties of mountain leather and mountain cork which (1) cannot be referred to asbestos on account of their large water-content, (2) cannot be identified with serpentinous asbestos on account of the relatively small amount of magnesia which they contain, and (3) hold their water in such a way that when it has been expelled by heating it is gradually re-absorbed to its original amount from the atmosphere.—Phenakite from Brazil; by Dr. G. F. Herbert Smith. Crystals of phenakite recently discovered at the gold-mine, San Miguel de Piracicaba, Brazil, all display the new form {2352} noted by other observers, and another {4596} lying near it. The tetrahedral character of the symmetry is clearly marked.—Preliminary note on the occurrence of Gyrolite in Ireland; by Mr. F. N. A. Fleischmann. The mineral gyrolite, though well known as occurring in the basalts of the Western Islands of Scotland, has not hitherto been recorded from Ireland. Specimens have now been found in the basalts and dolerites in the neighbourhood of Belfast. The mineral occurs in small spherical aggregates, forming a crust on faroelite; it is associated with apophyllite and occasionally with chabazite. The chemical composition and the optical characters of the mineral agree with those of gyrolite. The mineral is found only in the harder and denser layers of the basalt, and never in the soft highly amygdaloidal layers.

## II.—Geological Society of London.

*June* 16, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Carboniferous Limestone of County Clare." By James Archibald Douglas, M.A., B.Sc., F.G.S.

The district with which this paper deals forms the westernmost limit of the great central Carboniferous Limestone plain of Ireland.

The limestone floors nearly the whole of Eastern Clare, from the southern shore of Galway Bay to the banks of the Shannon. This area, for the purposes of description, is divided into two main districts.

The whole of the northern region is formed by a vast elevated plateau of Upper or Viséan Limestone, with a surface more than 100 square miles in extent, which rises on the north and east in steep terraced cliffs, but to the south-west dips gently below the so-called 'Coal-measure' Series. The surface of this plateau is formed of bare rock, devoid of vegetation and presenting the typical appearance of a Karst landscape. The rainfall is considerable, but is nearly all carried off by subterranean channels.

The southern district presents a totally different aspect. The high ground is no longer formed of limestone; that on the east being formed by Old Red Sandstone and Silurian rocks, that on the west by Coal-measures. The older formations appear as two anticlinal flexures, with a north-easterly trend, forming the mountains of Slieve Aughty and Slieve Bernagh, between which lies a broad syncline of Carboniferous Limestone. The margin of this syncline is formed by Tournaisian shales and limestone, the successive zones of which can be traced round its outcrop, while the Viséan limestones occupy the core. Much of the country is obscured by drift, chiefly derived from the underlying rocks.

A study of the limestone fauna shows that the Geological Survey boundary between the Upper and Lower Limestones corresponds with the transition from a Tournaisian to a Viséan fauna; the Lower Limestone cannot, however, be separated from the underlying shales; and the Middle or 'Calp' Limestone contains a fauna distinct from that of the Upper or Burren Limestone, although they are not separable on lithological grounds. An account is given of the zones recognized in County Clare, and a correlation made with the sequence in other British localities.

The Old Red Sandstone is succeeded, to all appearance conformably, by a thin series of sandy shales containing Brachiopods characteristic of the *Cleistopora* zone, at the base of which a band is found containing abundant Modioliform Lamellibranchs. The *Zaphrentis* zone is well developed, the *clathratus* subzone forming the top of the Lower Limestone shales, and the *koninckí* subzone the lower stratified limestone.

The most remarkable portion of the whole sequence is included in the *Syringothyris* zone, which is represented by massive grey and white mottled limestones, with a luxuriant molluscan fauna, large Cephalopods being especially abundant. These beds show evidence of deposition in shallow water, affording further proof of a mid-Avonian period of upheaval. The fauna is compared with that of the Waulsortian phase of Belgium. The incoming of a Viséan fauna is well marked at the base of the *Seminula* zone; in the middle of this zone occurs an important bed of Oolitic Limestone, with abundant Gasteropods. The *Dibunophyllum* zone attains a thickness equal to that seen in the Midland area. $D_1$ is chiefly characterized by the abundance of simple *Dibunophylla*, *Cyathophyllum murchisoni*, Clisiophyllid Lithostrotions, and *Productus latissimo-giganteus*; $D_2$ by the occurrence of *Lonsdalia* and *Cyathophyllum regium*; and $D_3$ by the abundance of Zaphrentids, *Caninia*, and Densiphyllids, and the apparent absence of Clisiophyllids and Lithostrotions.

An account of the chief fossil localities, under the headings of

the separate Baronies, is then given, and the paper concludes with palæontological notes.

2. "The Howgill Fells and their Topography." By John Edward Marr, Sc.D., F.R.S., F.G.S., and William George Fernsides, M.A., F.G.S.

The Howgill Fells form a monoclinal block, from which the Carboniferous rocks have been denuded. The gentle northern slope probably corresponds very closely with the sloping plane of unconformity between the Carboniferous rocks and the underlying Lower Palæozoic strata. On the south side, the steep slope to the Rawthey is along a block-fault, which has several minor parallel step-faults to the north. The chief drainage was originally north and south from the watershed at the summit of the block, but the swifter south-flowing streams have in several cases captured the head-waters of those flowing northwards, and thus the watershed has been largely shifted to the north. Some of these captures occurred probably in pre-Glacial times, but others undoubtedly took place in the Glacial Period, and others again are still proceeding. The tract was glaciated by its own ice, but 'foreign' ice was conterminous with the local ice on all sides.

The rocks are, from the point of view of errosive effects, nearly homogeneous, and a rounded form of feature was produced by weathering and stream-erosion in pre-Glacial times. The chief erosive effects of glaciation were the truncation of spurs; the formation of conchoidal scoops in the concavities of the valleys; a general widening of the valleys, and but slight deepening, as marked by the slight difference of grade (amounting to but a few feet) at the junction of tributaries with larger streams. A feature of interest is the contrast in this small area between these glaciated valleys and others of V-shaped cross-section, which are typical water-carved valleys unaffected by glacial erosion. The two great hanging valleys of Uldale and Cautley, where the streams plunge scores of feet down waterfalls, are due to river-capture, and not to the deepening by ice of the main valleys.

3. "A New Species of *Sthenurus*." By Ludwig Glauert, F.G.S.

In a large collection of remains of extinct Marsupial mammals from the Mammoth Cave, Margaret River (Western Australia), the author recognized several mandibles of a new kangaroo of the genus *Sthenurus*. He now communicates a detailed description of one specimen, and shows that the new species most nearly resembles *Sthenurus oreas* (De Vis) and *Sth. atlas* (Owen).

4. "Some Reptilian Remains from the Trias of Lossiemouth." By D. M. S. Watson, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

The fore-limb of *Ornithosuchus woodwardi* is shown in a specimen in the Manchester Museum. It is small, only about one-half the size of the hind-leg. The scapula is much expanded at both ends, and is indistinguishably fused with the coracoid. The latter bone is pierced by a large foramen. The humerus is a slender bone, somewhat twisted, but not much expanded at the ends; it has a distinct ectepicondylar groove. The ulna is very broad at the proximal end,

but narrows distally; its proximal portion forms a thin plate of bone. The radius crosses the ulna, its proximal end lying entirely in front of it, while the distal ends of the two bones lie side by side. The carpus cannot be made out. Only metacarpals 1, 2, and 3 are functional; but a possible representative of 4 lies closely pressed to the back of the other three. Both phalanges of digit 1 are preserved, the last being a strong claw.

*Ornithosuchus* is restored as an animal walking on all fours, with the head carried rather low. The proportions are identical with those of *Ætosaurus*.

A description is given of the skeleton of a very small reptile, interesting as recalling *Ætosaurus* in its armour, and because it shows the whole of the animal except the tail.

5. "Some Reptilian Tracks from the Trias of Runcorn (Cheshire)." By D. M. S. Watson, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

Very little information exists as to the tracks of the smaller reptilia of the Trias, although several types of footprints have been described from isolated examples. Four types of tracks which occur on the slab of sandstone from Weston Point, described in 1840 by Dr. Black, are discussed in this paper. They belong to forms generally included in the Rhynchosauroid types and to the footprint I, Beasley.

Both pes and manus are impressed in three of the cases, the other being so small that it is doubtful whether the manus would have made a recognizable impression if it did touch the ground.

Footprint A 2, Beasley, has a manus very similar to the pes, but showing some traces of the palm.

Footprint A 8, sp. nov., has five toes in the pes connected by a web. The manus is also five-toed, but corresponds to some extent to I, Beasley. There is a well-marked tail-streak in the track.

E, Beasley, which is very similar to I, really has five digits, the fifth being directed backwards and only just touching the ground.

A very small footprint is described as A 9.

It is suggested that some of these prints may quite well belong to such Thecodonts as *Ornithosuchus*.

6. "The Anatomy of *Lepidophloios laricinus*, Sternb." By D. M. S. Watson, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

A specimen of *Lepidophloios laricinus*, found in one of the coal-balls of Lancashire, shows the internal structure. The species is new, and is of the ordinary lepidodendroid type, but is remarkable for the great size and strength of the corona and the leaf-traces.

*Lepidophloios acadianus*, Dawson, which is identical with *L. laricinus*, appears to differ in its internal structure, in having still stronger protoxylem-points and leaf-traces.

*Lematophloios crassicaule*, Corda, which is *L. acerosus*, L. & H., appears to resemble greatly the Lancashire specimen of *L. laricinus* in its structure, and is quite distinct from the specimen of the same form described by Cash & Lomax.

*Lepidodendron fuliginosum*, Will., a structural species, appears to include a specimen the external structure of which corresponds with *Lepidophloios acerosus*, *Lepidodendron obovatum*, *L. aculeatum*, and *Sigillaria discophora*. Under these circumstances, it is proposed to take no account of the impression-species in considering the synonymy of the structural specimens, and *vice versa*. When the exterior of a structural specimen is actually known, it may be referred to by the name of the structural species, with that of the impression-species added in brackets.

Dr. G. F. Herbert Smith, M.A., F.G.S., exhibited two forms of refractometer. The one (which reads directly to the second, and by estimation to the third, place of decimals) has a range extending from 1·300 to 1·795, and is intended for all translucent substances, especially minerals. The other (which reads directly to the third, and by estimation to the fourth, place of decimals) has a range extending from 1·3200 to 1·4200, and is intended for use with water and solutions in water, especially brines, for which reason it may be called a salinometer. The liquid film is illuminated from above, and the optical arrangements are such that the critical edge is blue, if coloured at all, in white light. Since the refractive indices of liquids change rapidly with the temperature, a water-jacket is provided for controlling the temperature of the observation; a thermometer, reading to degrees Centigrade, is attached underneath the instrument. The glass prisms are removable for cleaning purposes.

The next meeting of the Society will be held on Wednesday, November 3, 1909.

## III.—The Royal Society.

Ordinary Meeting, *June* 24, 1909.—Professor J. Cossar Ewart, Vice-President, in the Chair.

"The Possible Ancestors of the Horses living under Domestication." Part I. By J. C. Ewart, M.D., F.R.S.

By some naturalists it is believed that domestic horses are the descendants of a Pleistocene species (*Equus fossilis*), now represented by the wild horse (*E. przewalskii*) of Mongolia; by others the horses living under domestication are said to be a blend of a coarse-headed northern species allied to Prejvalsky's horse and a fine-limbed southern species which in prehistoric times inhabited North Africa, or a blend of a Prejvalsky-like northern species and a southern species closely allied to *E. sivalensis* of the Pliocene deposits of India. The examination of the skull, teeth, and limb bones of horses found at Roman settlements and in the vicinity of pile dwellings indicates that domestic horses originally belonged to several distinct types, viz. (1) a type characterized by long limbs, by a long face, broad and convex between the orbits, and strongly deflected on the cranium, and by the crown of the fourth premolar being from before backwards about 2·5 times the length of the grinding surface of its 'pillar'; (2) a type with slender limbs, a fine, narrow, slightly deflected face, and the crown of the fourth premolar about three times the length of its 'pillar'; (3) a type with fairly slender limbs, a long, narrow,

somewhat deflected face, and the crown of the fourth premolar about twice the length of its 'pillar'; (4) a type characterized by short broad metacarpals, a short face, broad and flat between the orbits, and nearly in a line with the cranium, and by the crown of the fourth premolar being twice the length of its 'pillar'; and (5) a type with short wide metacarpals, the face long and strongly deflected, and the crown of the fourth premolar about 1·5 times the length of its 'pillar'. Only the varieties characterized by molars with short 'pillars' are dealt with in this communication. The possible ancestors of the short-pillared varieties are *Equus sivalensis* of Indian Pliocene deposits, *E. stenonis* of the Pliocene deposits of Europe and North Africa, and a new species, *E. gracilis*.

Arabs, barbs, thoroughbreds, and other modern breeds with a long deflected face, broad and prominent between the orbits, and the limbs slender, seem to have mainly sprung from *E. sivalensis*, while certain unimproved breeds, with a deflected face but very short 'pillars', are probably related to *E. stenonis*. Exmoor, Hebridean, Iceland, and other ponies of the 'Celtic' type, as well as ponies found in the South of France, the West Indies, and Mexico, characterized by a fine narrow skull, slender limbs, and the absence of ergots and hind chestnuts, are regarded as the descendants of *E. gracilis*, which includes (1) the small species of the English drift described by Owen as a fossil ass or zebra (*Asinus fossilis*); (2) the small species of French Pliocene and Pleistocene deposits known to palæontologists as *E. ligeris*; and (3) the small species of North African Pleistocene deposits known as *E. asinus atlanticus*, and hitherto believed to be closely related to, if not the ancestor of, zebras of the Burchell type. By crossing experiments evidence has been obtained of the wide distribution of horses of the *E. gracilis* type; that broad-browed Arabs and thoroughbreds with the face nearly in a line with the cranium are mainly a blend of a southern variety of *E. gracilis* (*E. caballus libycus*) and a horse of the 'forest' or Solutrè type, and that heavy breeds have not inherited their coarse limbs from a species closely allied to the wild horse of Mongolia.

## CORRESPONDENCE.

### VORTICOSE MOVEMENT IN THE EARTHQUAKE OF BENAVENTE, PORTUGAL.

Sir,—On May 14 I visited the well-known convent of Batalha (6 miles south of Leiria) in Portugal. On ascending to the roof the caretaker drew my attention to the effect on the building of the earthquake of Benavente, which occurred at 5 p.m. on April 23, 1909. The roof (of stone) is adorned with numerous four-sided pyramidal Gothic pinnacles. In two of these, while the lower part of each pinnacle has retained its original place, the upper part has been displaced by the earthquake and partially rotated, so that the angle of the upper part, facing (say) north, is turned through part of